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LIST OF PLATES.

ERRATA.

Page 147, line 21 from top, *for* "galvanism" *read* electricity.

Page 173, line 18 from bottom, *for* "cold" *read* "dry."

QUARTERLY JOURNAL

OF THE

ROYAL METEOROLOGICAL SOCIETY.

VOL. XII. JANUARY 1886. No. 57.

THE HELM WIND OF AUGUST 19TH, 1885. By WILLIAM MARRIOTT, F.R.Met.Soc., Assistant Secretary.

[Read November 18th, 1885.]

AT the request of the Council I visited the Helm Wind district on August 19th to 21st last, in company with Mr. T. G. Benn, F.R.Met.Soc. We drove through most of the villages between Cross Fell and the river Eden, and also went over Hartside Fell to Alston, on the eastern side of Cross Fell.

We made numerous inquiries at each of the villages as to the appearance of the Helm Cloud, the Helm Bar, the peculiarities of the wind, and its effects, &c. By this means we obtained a great deal of information of the havoc Helm Winds were reported to have done; it was, however, very difficult to reconcile all these statements, and to form a correct idea of the phenomenon. We were frequently told that haystacks were sometimes overturned, men on horseback blown out of the saddle, and other damage done by the wind. A lady informed us that once when travelling in the train on the Midland Railway, near the foot of the Fell, when the Helm was on, she saw a great quantity of soil in a field close by carried up into the air by the wind.

We also learnt that a statement had appeared in a local newspaper that on one occasion the Midland Pulman express train was stopped by the fury of the Helm Wind. On making inquiries at the railway station where this was reported to have happened, we were informed that no such occurrence had taken place, and that it could only have existed in the imagination of the

reporter. The railway officials, however, stated that the engine drivers have great difficulty in getting along with their trains when the Helm Wind is blowing.

At very few places could we get precise information as to what the persons had *actually* seen or experienced: the statements being very vague, or consisting of what they had been told by other people. The conclusion we arrived at was that past accounts were of little value, and that observations must be made on a systematic plan in order to obtain reliable data to throw light on the cause of the Helm Wind.

By reference to a map of the district, it will be seen that the Cross Fell range is continuous, and runs from North-north-west to South-south-east without any break or valley until its termination at Brough. On the east, for the most part, there is a high table land with dales and valleys, but on the west there is an abrupt fall of from 1,000 to 1,500 feet in about a mile and a half. At the foot of Cross Fell on the west there is the Vale of Eden, a plain some twenty miles broad extending to the hills in the Lake district.

The chief features of the phenomenon are the following:—On certain occasions when the wind is from some Easterly point, the Helm suddenly forms. At first, a heavy bank of cloud rests along the Cross Fell range—at times reaching some distance down the western slopes, and at others hovering above the summit; then at a distance of one or two miles from the foot of the Fell there appears a slender roll of cloud suspended in mid-air and parallel with the Helm Cloud; this is the Helm Bar. A cold wind rushes down the sides of the Fell and blows violently till it reaches a spot nearly underneath the Helm Bar, where it suddenly ceases. The space between the Helm Cloud and the Bar is usually quite clear, blue sky being visible; at times, however, small portions of thin vaporous clouds are seen travelling from the Helm Cloud to the Bar. The Bar does not appear to extend further west than the river Eden.

Fig. 1 gives a section of the Cross Fell range and the Eden valley, and shows the position of Helm Cloud and the Bar, with the direction of the wind. I am indebted to Mr. R. W. Crosby, of Kirkby Thore, for this diagram, and he says that sometimes the whole valley is covered with a sheet

FIG. 1.

HELM WIND.

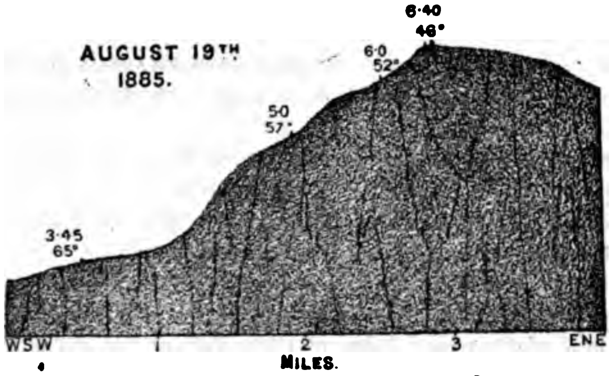
SECTION OF CROSS FELL RANGE AND THE EDEN VALLEY SHOWING POSITION OF CLOUDS.

of cloud which stretches from the Bar to the Helvellyn Range. Through the clear space between the Helm Cloud and the Bar, clouds at a considerable altitude are sometimes seen, which appear to be nearly stationary.

On August 19th, Mr. Benn and I ascended Cross Fell in company with Mr. R. W. Crosby and his nephew, and when descending in the evening we were so fortunate as to witness a slight Helm. We left Kirkland at 3.45 p.m., when the temperature of the air was 65°, the wind blowing lightly from the North-north-east. At 5 p.m. we were 1,950 feet above sea-level, the temperature being 57°, and the wind blowing steadily from North-north-east, force 4. By 6 p.m. we had reached 2,670 feet above sea-level, when the temperature was 52°. We gained the summit, 2,930 feet above sea-level, at 6.40 p.m., a few minutes before a mist came on and obscured the view on the east side of the Fell. The air became much colder and damper, and the wind stronger; the temperature was 46°, and the wind North-north-east, force 5.

Fig. 2 gives a section of Cross Fell, with the temperatures observed during the ascent from Kirkland to the summit of the mountain.

FIG. 2.



SECTION OF CROSS FELL WITH TEMPERATURE OBSERVATIONS.

This sudden fall in the temperature was the first indication of the formation of the Helm; the misty cloud soon covered the top of the Fell, and the wind increased in force as we descended till it reached force 6. About 8 p.m. we saw the Helm Bar suspended in mid-air a little below our level, but away over Melmerby, Ousby, Kirkland, Milburn, &c.

I have endeavoured in Fig. 3 to give a rough sketch of the Bar as seen from Cross Fell. The Bar was really in two parts, there being a decided

FIG. 3.

HELM BAR. AS SEEN FROM CROSS FELL AUGUST 19, 1885.

clear space between them. The northern portion of the Bar had a tendency to move southwards, while the southern portion had a tendency to move northwards. The middle of the Bar appeared to be nearly over Kirkland, while the northern extremity reached to about Renwick, and the southern extremity to Knock Pike. Although the Bar appeared to be nearly stationary it was quite evident that there was much commotion in the cloud itself, as portions of the upper and lower surfaces were whirled about in all sorts of ways. We saw this commotion to advantage, as the moon was behind the cloud during the greater part of the time we were descending the mountain. Just before reaching Kirkland at 10.30 p.m. we became conscious that the wind had suddenly ceased and that the air was much warmer. This fact seemed so strange that Mr. Benn went back about fifty yards and there found the wind blowing quite strongly from the Fell, while where I was standing the air was calm or nearly so, with an occasional light puff of wind from the South-west. The Helm Bar was now nearly overhead. This seems to show that under the Bar there is an upward current.

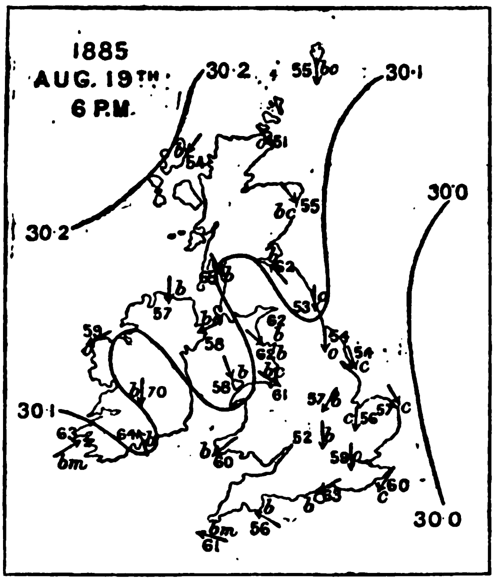
Mr. Crosby, who left us at 7.15 p.m. to return to Kirkby Thore, while Mr. Benn and I proceeded northwards to Ardle Head Mine, observed the same peculiarities. He writes: "In coming down the face of the ledge I noticed little scraps of vapour beginning to condense in the clear space South-west of us, and remarked to my companion that we should probably get out of the wind before we got home, as there was a very strong indication of the setting of the Helm Bar.

"We crossed the stream forming the County Boundary, about 300 yards above the fence wall of the Fell, and followed the track along the outgang towards Milburn. The condensing was still going on, and there was now a slender string of cloud standing over Milburn-town head;—the white mist was clinging close to the Fell tops, and all the other parts were clear, the slender Bar stretching from about Howgill Castle to Kirkland, at about the apparent level of the second ledge of Cross Fell, or that of the Silver Band Mine. About half way between the Fell foot and Milburn, say ¾ mile from the Bar, we suddenly became aware that we had lost the wind and it was dead calm,—so still that a lighted candle might easily have been carried bare. We searched our pockets for matches to test it, but unfortunately they were not there; however, though we did not actually prove it, we were both certain that it could have been done, and we had ocular demonstration a little later. We stopped and listened, and the peculiar sighing, murmuring sound of the Helm Wind could be distinctly heard, coming from the quarter where we parted with our friends. The sound was not loud,—the whole affair being of course on a much smaller scale than it often is; but the characteristics of the Helm Wind were plainly there. The air, which had been very cold, was now warm and balmy as a summer evening, and before we got 200 yards from the place where we first noticed the calm we met several very light puffs of air from the South-west. We reached Milburn about 8.45 p.m., the Bar being directly overhead just before we entered the village. It was now dark except for the moon, and as we passed the School, one of a group of men

sitting on the step struck a match to light his pipe, but hearing our footsteps he turned and had a good look at us, holding the pipe in one hand and the match in the other. After satisfying his curiosity he kindled his tobacco without losing his light, and so demonstrated the perfect stillness of the air at that point. We took the road by Milburn Mill and Hale Grange to Kirkby Thore; just after passing the Mill we had a steady breeze from South-west for about five minutes, force about 3; but on the whole it was calm all the way home, where we arrived at 9.45 p.m."

The Daily Weather Chart for 6 p.m. is represented in Fig. 4. From this it is seen that fine weather prevailed over the greater part of the British Isles; the only part covered with cloud being the North-east coast of England.

FIG. 4.



Weather Chart.

Having witnessed a Helm on a small scale, I have been better able to prepare the following form for the record of observations during the occurrence of the Helm Wind.

1. Apparent position of the Helm Cloud relative to the summit of Cross Fell, whether above the top or how far down the slope of the mountain.
2. Apparent position of the Bar :—
   a. Whether to the east, west, or overhead of the observer.
   b. The extremity of the Bar on the North.
   c. The extremity of the Bar on the South.
   d. Whether the North and South ends are joined by clouds from the Helm Cloud.
3. Direction of Wind at place of observation.

4. Direction from which the higher clouds are moving (if any).

5. If any clouds or vapour are seen near the Bar, specify their direction and movements.

6. General conditions of Weather at the time.

7. If any change has taken place in the temperature or feeling of the air, state when it occurred and what was its nature.

8. Instances of exceptional wind-force in locality.

9. Special remarks.

Before leaving Newton-Reigny, I was informed that the Penrith and District Literary and Scientific Society would hold their Autumn Field Day on September 10th, when they would ascend Cross Fell. As the Secretary was desirous of obtaining a Paper on the Helm Wind to be read on that occasion, I called upon him, and after some conversation with him, agreed to write a short Paper describing my observations on the Helm Wind of August 19th. At the conclusion of the Paper I solicited the co-operation of the Members in making observations, and said "that much valuable information could be obtained if some six or eight gentlemen would go out in pairs during the occurrence of the Helm Wind and make observations with thermometers, &c. on each side, and beneath the Bar, and at various places. Such observations would throw much light on the movement of the currents near the Bar."

I am very pleased to say that this suggestion has been taken up, and that eight Members of the Society have agreed to go out and make observations when the Helm is on.

In conclusion I have to express my best thanks to Mr. Benn for the ready and valuable assistance he rendered me in this inquiry.

DISCUSSION.

Dr. A. WOEIKOF in a letter to the Secretary said :—" In the July number of the *Quarterly Journal*, Vol. XI. p. 226, which reached me a few days ago, I notice a Paper and discussion on the Helm Wind, which interested me very much. The numerous descriptions of this wind, all or nearly all agreeing in describing its violence, its local limitation, and the atmospheric conditions accompanying it, have led me to the following conclusions, which I would lay before the Royal Meteorological Society.

" In short, my conclusion is that the Helm Wind is identical in character with the Bora. There are two regions of the old continent where the Bora blows: (1) the coast of Istria and Northern Dalmatia; and (2) the East coast of the Black Sea, north of 44° lat., especially the Bay of Novorossisk.

" In all descriptions of the Bora we notice the suddenness of the occurrence of the wind, and the sharply-defined cloud-band on the mountains, while the weather is generally clear below. As to the Bora of the Black Sea, I give the following translation from my book on the *Climates of the World*:—' Seamen call the Bora an air-cascade. There is reason to think that it begins when the equilibrium of the air is disturbed, till when it is more than 6° C. colder on the crest of the Varada mountains than over the bay.[1] These mountains slope away gently to the North-east, towards the broad Adegoa valley, which is walled in on the other side by the Swinzowaja chain. In the autumn and winter it is much colder in the valley than on the sea-coast, and when the cold air fills the valley to overflowing, the equilibrium of the air-strata becomes unstable, and the greater the difference of temperature the stronger becomes the Bora.'

[1] They rise about 600 metres above the sea.

"In the passage quoted above only one case is considered, viz. cooling by radiation of the air to the North-east of the bay, but a strong Bora may also arise when there is a general though not strong North-east wind to the north of the Caucasian chain. The Varada mountains prevent this wind, for some time, from reaching the sea-shore. The contrast of temperature is intensified thereby, and the Bora breaks out the stronger when the hindrance is overcome. This explanation of the Bora was first given by Baron F. v. Wrangell,[1] and he has calculated the velocity of the wind which would result from given differences of temperature. If the lowest part of the Varada chain be taken as 550 metres, the temperature at sea-level 0° C., and at the given height —10°, it would be equal to 172 metres per second; if it be 0° at sea-level and —15° at the height, the wind would have a velocity of 22·1 metres per second. In both cases the friction is not taken into account; it certainly must not only lessen the velocity but also cause whirls and eddies, as well as sudden changes in the velocity and direction of the wind. These phenomena are really observed in Novorossisk, where the direction of the wind during the Bora oscillates between East-north-east and North-north-east.

"Now returning to the Helm Wind, I find it very probable that, as the phenomena are the same as those of the Bora, and the direction of the wind nearly identical, the cause must be the same. The isotherms of the British Islands show a much lower temperature on the east than on the west of the Pennine chain during the months from November to April. This difference is certainly greater with East winds and clear weather, and it is very likely that the difference of temperature between the Penrith Valley and Cross Fell may frequently be greater in such weather than that which admits of an unstable equilibrium. If this view of the case be right, a very few observations of temperature could settle the question. A meteorological station should be established at Penrith, and, if the observer has leisure and interest for the question, he would certainly make more frequent observations on days with Helm Wind. Another observer could make occasional observations on such days on the Cross Fell with a sling thermometer (*Thermomètre fronde*). I have no doubt that my hypothesis on the identity of the Helm Wind and the Bora, and the existence of an unstable equilibrium of the air-strata during the prevalence of the Helm Wind, would be confirmed by such observations. There are some additional reasons for thinking so. There is scarcely a case of Helm Wind observed in summer, though East winds are not wanting, and that is because at this season the East of England is rather warmer than the West. If the cases of Helm Wind are less frequent in the winter months than in November, March and April, it is because East winds are less frequent, and the prevailing West winds bring cloudy weather, during which no unstable equilibrium of the air-strata in the vertical plane arises."

On the receipt of this letter Mr. MARRIOTT had forwarded to Dr. Woeikof a copy of his observations, and asked him if they confirmed his impression that the Helm Wind was similar to the Bora.

In reply Dr. WOEIKOF wrote:—"I think your observations on the Helm Wind are very interesting, and quite confirm my opinion as to the existence of a greater fall of temperature than that answering to an unstable equilibrium."

Mr. ATKINSON said that he was very familiar with the Helm Wind, having resided in the district for the greater part of the first twenty years of his life. At that time, however, he did not make any careful observations, but since then he had on different occasions had opportunities of noticing it, and quite recently (October 28th and 29th) when in the district he had witnessed an occurrence of the Helm. Mr. Marriott had shown that when the Helm was on, the sky was sometimes clouded over, excepting the space between the Helm Cloud and the Bar, which was usually quite clear, blue sky being visible. This was quite correct, and travellers by the North Western Railway could generally know when the Helm was on by seeing a narrow patch of sunlight extending for some distance near the foot of, and parallel with the Cross Fell range, when the sky was elsewhere overcast. On the last occasion of his witnessing the Helm this band of sunlight, which he had hitherto believed was always parallel with the mountain range, was farther northward than usual, and instead of being parallel with it, lay crosswise along the range from about North-west to South-east. He thought this was a peculiarity worth calling attention to. He could confirm Mr. Marriott's

1 "Ueber die Ursache der Bora in Novorossisk." *Repertorium für Meteorologie*, Vol. V.

opinion as to the probably greater strength of the wind through the gorges in the range, as he had heard of some wonderful instances of wind force exerted at the foot of one of these gorges or gullies.

Mr. ABERCROMBY said that in September last he had spent a few days in the Helm Wind district. He saw Mr. Benn, who had the local superintendence of the Helm Wind investigation, and learned from him that fourteen gentlemen had volunteered to go out, when the Helm was on, to various places and make observations as to the conditions of weather prevailing. He (Mr. Abercromby), however, was not fortunate enough to witness an occurrence of the Helm Wind, but he had made inquiries respecting its peculiar character and violence, and had found out some interesting particulars regarding it. He had got one gentleman to promise to take a photograph of the clouds when the Helm was blowing, as he believed the only way to obtain good cloud pictures was by means of photography. In the course of his inquiries he came across an old lady who, when questioned as to what she knew of the Helm Wind, described it as blowing round in the shape of an egg; but when asked which way the egg was supposed to lie, she could give no satisfactory answer. Most likely the wind blew down the Fell, up into the Bar and back again to the summit of the Fells. With respect to the cause of the phenomenon, he agreed so far with Dr. Woeikof as to believe that it was partially due to the unusual difference of temperature between the foot and top of the mountain, as observed by Mr. Marriott, but this he felt sure was not the only cause. The origin of the cloud was certainly partly dynamical, or due to some aerial eddy or *ricochet* on the lee side of the Fell, and he thought that the only way to get at the bottom of the matter was to work out the idea contained in the recently published Report of the Committee, that the cases of East wind over the district when the Helm Wind did not occur should be investigated as well as the cases of prevailing East winds *with* the Helm Wind. By that means some characteristics, peculiar to one case and not to be found in the other, might be discovered which would afford a clue to a solution of the whole question.

Mr. SYMONS referred to a letter from Dr. Woeikof published in the previous week's issue of *Nature* comparing the Helm Wind with the Bora of the Black Sea, and in which he claims that the Bora and Helm being so identical as regards details of force and area, and time of prevalence, it is not unreasonable to presume that their cause is also identical. The Bora is shown to be caused by a disturbed equilibrium of air temperature, and Dr. Woeikof then goes on to show that the Helm Wind is due to the same cause, demonstrating his case in a clear and able manner. He (Mr. Symons) then read a brief summary[1] of the paper on the Bora by Baron v. Wrangell, referred to by Dr. Woeikof, in which a clear explanation of the nature of the Bora is given, and the whole question thoroughly worked out. With respect to the Helm Wind, it had been seriously proposed by one gentleman that pipes should be laid up the side of Cross Fell, and when the Helm Cloud was forming quantities of steam should be let off at the top of the Fell by means of these pipes, and so cause the accumulated vapour to disperse. In considering the means of getting rid of the Bora, Baron v. Wrangell proposed a plan somewhat analogous to this. His plan was to cut a deep gorge through the Varada Mountains, which lay at the back of the town of Novorossisk, and so make a way of escape for the air which accumulates at the back of this range and causes all the mischief. It appears that the town is admirably suited for a port, as the bay on which it stands affords ample shelter for ships, and besides this it has great advantages over any place in the neighbourhood for the shipping of cargoes, but the great violence of the Bora prevents

1 Before the Bora the Eastern heights of the Varada Mountains are always cloudless. Some time before the bursting of the Bora small white clouds begin to form on the top of the mountains, their number increases, and a strong motion among them is evident. The air is in commotion, strong gusts follow one another from opposite directions. After a time single clouds here and there tear themselves from the mountain and precipitate themselves into the deep, but half way down they disappear. With incredible violence whirlwinds precipitate themselves from the mountains, while a dense salt mist of whipped-up sea water fills the air and covers every thing on board ship with a crust of ice. On land it is dangerous to remain out of doors, owing to the shower of falling bodies, stones as big as one's fist, iron roofs, &c.; strong buildings tremble under the frightful force of the wind.

The destructive force of the wind is felt only on the coast and close to the mountain, but especially in Novorossisk, and the effect of the Bora ceases a little way from the coast.

On the other side of the Varada Mountains the wind is only light, indeed at some distance it is often perfectly calm.

its being used as a port by Russian vessels. There is a town a short distance off which is situated opposite a valley in the mountain range, and at this place the Bora is not felt with any thing like the force with which it blows at Novorossisk, and Baron v. Wrangell believes it would cost less to cut a gorge through the mountains at Novorossisk than it would to construct a harbour at the former town.

Mr. ARCHIBALD said although it was probable, as Dr. Woeikof had intimated, that the Helm Wind and the Bora were very similar, there were details in the Helm Wind which had no corresponding analogues in the Bora. Thus the Helm Bar was not noticed as occurring in the Bora. This appeared from the diagram to be due to the current being deflected upwards by the rising ground below Cross Fell before it reached the bottom (as would occur according to well-known hydro-dynamical principles), the cloud being produced by condensation in the ascending current. The clear space between the Bar and the Helm Cloud he thought was evidently due to the descending air precluding condensation between these points. Similar valley drainings and cataracts occurred in the Himalaya, where in the higher passes the wind was so violent that persons were obliged to lie down to prevent being blown off their feet.

Mr. C. HARDING said that a most instructive point to learn in connection with this Helm Wind investigation was the relative distance of the Bar from the Helm Cloud. The accounts he had read varied very much in this particular, and he should say that the Bar certainly was not in a fixed position. It was very desirable to know the exact conditions of weather prevailing over the whole country in making an investigation of this character. He had read Dr. Woeikof's letter in *Nature*, but could not see that there was much similarity between the Bora and the Helm, as the Bora apparently, in the instances given, was blowing out to sea. It was to be regretted that Mr. Marriott had made no observations of temperature during the descent. He believed that the best way to settle the question was for gentlemen in the district to go out when the Helm was on and make observations, as he felt sure more could be learned from such observations than from a continuous series of general observations extending over a number of years. His own theory as to the cause of the phenomenon was that it was the result of suction, and he was inclined to think that the particulars they knew respecting the peculiarities of this wind fully bore out this view ; at any rate he believed the theory was worthy of some notice. There are the Helm Cloud and the Bar, the air rushing down the western slopes of the Fell, and the calm at the foot with the upward tendency of the wind towards the Bar. The direction of the wind was generally East, and his idea was that the wind blowing over the top of the valley induced a certain amount of suction from the air in the valley : a partial vacuum is set up, and immediately the downward stream of air from the summit of Cross Fell into the valley sets in.

Mr. LECKY said that he could not accept the theory of suction, and his opinion on the matter was that the wind travelling up the eastern slopes of Cross Fell meets with a cold stratum of air at the top and became condensed into fog, which on descending the increasingly warmer western slopes, as shown by the arrows on the diagram, become again absorbed, and meeting with still warmer and damper air in the valley ascends until condensed in a cooler stratum, thus forming the Bar.

Mr. DYASON was somewhat surprised that no mention had been made of the possibility of the phenomena being due to electricity ; he thought it probable that electricity had as much to do in forming the Helm Bar as the wind.

Mr. LAUGHTON remarked that some of the speakers had, he thought, made rather too much of the difference between the temperature at the summit and base of the mountain. It should not be forgotten that there was a difference of nearly three hours in the time of observations ; and it was quite possible that a great part of the 19° shown on the diagram was the difference, not between base and summit, but between 3.45 and 6.40 p.m.

The PRESIDENT (Mr. Scott) said that in his opinion Dr. Woeikof was not the first person who had compared the Helm Wind to the Bora. Dr. Woeikof had confined himself to the Bora of the Black Sea, and of Istria and Dalmatia, but the Bora also blew at Trieste with such fury that in some streets ropes were said to be placed to serve for handrails. Dr. Jelinek had once traced a Bora from Trieste back to Vienna. A reference to Hann's *Climatology* showed that

the essential characteristic of the Bora was, that it was a descending wind, and that a cloud cap was formed on the mountains before it burst forth.

Mr. MARRIOTT, in reply, said that the reason that observations were not taken during the descent was that he had the misfortune to sprain his ankle, and besides that it was too dark to read the thermometers. In fact, the observations made on the ascent were taken for curiosity rather than for any other reason. as he did not know that he was likely to witness an occurrence of the Helm Wind. No reference had been made in the discussion to the peculiar motion of the Bar, both halves seeming to be moving towards each other. This motion was, he thought, caused by the wind sweeping round at both ends of the range, where the ground was somewhat lower. So far as he was able to observe, there were no signs which would lead him to suppose that the phenomenon was in any way due to electrical agency.

THE TYPHOON ORIGIN OF THE WEATHER OVER THE BRITISH ISLES DURING THE SECOND HALF OF OCTOBER, 1882. By HENRY HARRIES. (Plate I.)

[Read November 18th, 1885.]

THE sudden arrival of a severe gale over the south-east of England on the morning of October 24th, 1882, completely upset the forecasts issued from the Meteorological Office on the previous evening, and this failure was severely criticised at the time. It will be shown later on that with our existing knowledge it was impossible to forecast it from the 6 p.m. observations of the 23rd.

The disturbance was undoubtedly a secondary one, developed within the area of a very large cyclone which had its centre in about 60° N, 20° W, and it is the track, or rather tracks, of this primary which I am about to discuss.

Through the kind permission of the Meteorological Council I have been allowed access to all the sources of information in the Meteorological Office, including the elaborate charts of the North Atlantic. I am indebted to Dr. Neumayer for many observations in the North Pacific, made on board ships keeping logs for the Deutsche Seewarte; and to the Chief Signal Officer at Washington for a copy of unpublished observations made at nineteen stations in Alaska and its neighbourhood.

It may be taken for granted that the change from the South-west to the North-east Monsoon season occurs towards the end of September, the area of low barometer over the Asiatic continent being replaced by an anticyclonic area. This is well shown by the reports of the Zi-ka-Wei observatory; where the barometer seldom reaches 760 mm. (29·92 ins.) before September 21st, the last ten days of the month averaging considerably above that reading, and continuing so throughout the winter. The period of change is marked by violent typhoons in the same manner as the South-western part of the Atlantic is visited by hurricanes about the same time of the year; *i.e.* the commencement of the anticyclonic conditions over Asia and over North America, which mark the approach of winter, indicates the probable birth of cyclonic disturbances on their South-eastern sides.

Unfortunately the part of the Pacific lying between the Philippine and the

Sandwich Islands is very little frequented by shipping, and I am therefore unable to give direct evidence of the commencement of the typhoon; but from a consideration of the data collected, it appears that it began to form on September 27th. As early as the 10th an exceptionally violent hurricane raged in 16° N, 114° W. Moving slowly to the westward it caused severe damage to ships in its path, but after the 12th, in 18° N, 122° W, all trace of it is lost. I do not suggest that it had any thing to do with the typhoon which showed itself a fortnight later in 134° E.

M. Deschevrens, in his *Typhoons of 1882*, Part II. Plate 1, lays down the track of a typhoon commencing near the Philippines on September 20th, he then carries it westwards across the islands, thence north-eastwards to the south of Japan by the 25th, then recurving to the southward brings it on the 29th to the neighbourhood of its starting point of the 20th. The line is then taken north and north-eastward, past the south-eastern point of Japan into the Pacific. In the Washington *Bulletin of International Meteorology* for June 1884, this track is adopted in the Appendix devoted to September, 1882, while on page 11 of the same Appendix it is stated that "Number XXVI. appeared near the eastern coast of Yesso on the 28th, and moved into Behring Sea at the close of the month." It is clear, however, that M. Deschevrens has, from want of sufficient observations, fallen into error in taking his curve to the south after the 25th. The disturbance having passed along the Japanese coast into the Pacific, was, in reality, the Washington Number XXVI., which it will be seen was overtaken by the typhoon we are about to discuss. As these tropical storms pass into higher latitudes the barometer in the tropics resumes its ordinary condition, which is low in relation to what is to the north, and I fear that to this fact is to be attributed M. Deschevrens's great tendency to bring back his typhoons to their starting point. It has misled him into saying on page 20 of the same publication "we must acknowledge that such atmospheric cyclones may keep for months in the same quarters, and that at any time of the year." The equatorial belt of low pressure is not cyclonic, and strictly speaking it is not an area of low pressure in the generally accepted sense. Although differing from M. Deschevrens in his conclusions, I am bound to acknowledge the great value of the observations he has collected, and which have been of no little service in the preparation of this paper.

Since September 21st, an anticyclone had been gradually creeping across Siberia from Europe; and as this had an important influence on the typhoon, being, as I believe, the reservoir from which it was supplied with energy, its course has been shown on the track chart until it reaches Mid-Atlantic. On the 26th its centre was near 60° N, 112° E, the maximum pressure being at least 30·65 ins. At the same time several areas of low barometer existed along the seaboard of Eastern Asia. The barometer was below 30·0 ins. all over the sea south of Japan. By the 27th a great and important change had taken place, the areas of low pressure were disappearing, and the anticyclone had moved to the south, the barometer at Pekin rising 0·5 in., and at Macao, within the tropics, to the extent of 0·1 in. The

mercury was above 30·0 ins. to the edge of the tropics. At Manilla, in latitude $14\frac{1}{2}°$ N, this change of pressure was not felt. The result of the alteration in the prevailing condition of pressure was a marked decrease of temperature, the colder air brought down from Siberia reducing the temperature over Japan by more than 10°, while at Manilla the maximum temperature of the 28th was 9° lower than on the 27th, the mean for the day being 5°·6 lower. The warm air of previous days had ascended into the upper regions, producing an atmosphere highly charged with vapour, and forming clouds. In consequence of the increase of gradient for Easterly winds, due to the changes of pressure already alluded to, a state of affairs would be produced favourable to the formation of an atmospheric disturbance, an increase of wind, and condensation. In the early part of their career tropical storms do not seem to me to be cyclonic, they are perhaps more nearly related to the subtropical anticyclone until they become detached from the equatorial belt of low pressure, and the circulation of the wind becomes complete. The North Atlantic Weather Charts contain several instances of this phenomenon, which cannot fail to attract attention in connection with West India Hurricanes.

The earliest evidence of the existence of the typhoon is contained in the Manilla reports for the 27th. In the evening, with a light variable wind, the barometer began to fall, feathery cirrus appeared to the East-south-east, and a lunar halo was visible.

On the 28th the wind was North, the barometer still falling, with an overcast sky and heavy rain, the Remarks for the day stating that a centre of minimum pressure lay to East-south-east. In 18° 46′ N, 132° 8′ E, the American barque *Samuel D. Carleton* was experiencing very strong winds from East and East-north-east, barometer falling to 29·80 ins. and heavy rain. In the Formosa Channel and China Sea the wind was rising, strong to a gale, from East and North-east. The disturbance was moving North-westward very slowly, not more than five miles an hour, the anticyclone moving towards it.

On the 29th the typhoon was making itself evident as far as Zi-ka-Wei, the record being "barometer falling, a typhoon coming up from the South." The centre, however, was about 1,000 miles away at the time. At Manilla the wind had changed to South-south-west, the barometer had fallen to 29·67 ins., and solar and lunar halos were recorded. The *Samuel D. Carleton*, in 19°2′ N, 129°52′ E, had still a strong East-north-east wind with the barometer down to 29·58 ins. and continued heavy rain. A moderate North-east gale was felt in the Formosa Channel, off Shanghai the wind was becoming squally, and in the southern parts of Corea and Japan rain had set in with squally, gloomy weather; the rainfall at Nagasaki amounting to $1\frac{1}{4}$ inch. The anticyclone over the mainland was being gradually reduced, the maximum reading being about 30·4 ins.

The observations of the 30th show that the *Samuel D. Carleton*, in 18°41′ N, 130° E, had the barometer down to 28·85 ins., with deluging rain and a hurricane from North-north-west, the wind in six hours changing from East-

north-east, through North-east and North, to West by South. About a mile from the ship a waterspout was seen. Along the northern coasts of Luzon a North-west hurricane was raging; at Kelung, on the north of Formosa, a North to North-east heavy gale was reported. The rainfall at Nagasaki amounted to 1·67 in., and at Tokei to 2·9 ins. As far west as Macao a moderate North-north-west gale was blowing. In a north-westerly direction from the centre several ships recorded heavy to moderate North to North-east gales as far as the Shantung Peninsula, a distance of more than 1,300 miles. An Easterly gale was being felt as far as Yokohama, over 1,000 miles to the north-east of the centre.

These statements differ very considerably from what various authorities give as to the extent of typhoons, the diameter, according to Labrosse, being between 60 and 200 miles; while Raper gives 60 to 250 miles, and Piddington 50 to 500 or even 1,000 miles, the limits of the true cyclone circle being 12° from the centre, which gives a diameter of 1,400 to 1,500 miles. Knipping gives 700 miles. In the case now before us the gale was reported at the distance of at least 1,300 miles from the centre towards the north-west, and 1,000 miles to the west and north-east. With a reading of 28·85 ins. in lat. 19° N, we may be sure that steep gradients for Westerly and South-westerly gales existed on the equatorial side of the centre; but as no observations are available it is unsafe to estimate the area under the influence of gale force on that side. In the case of a large depression which existed off the Bay of Biscay, in 44° N, 15° W, on December 11th, 1882, gales prevailed for more than 1,000 miles on the western and south-western sides, while to the north-east they were not felt further than 100 miles from the centre.

Between September 27th and 30th the typhoon had made but slow progress, its rate being only five miles an hour for the first two days and ten miles an hour on the third day. The anticyclone meanwhile had travelled southward to near Wladiwostock, the barometer readings at the centre being nearly half-an-inch lower (30·2 ins.). By October 1st the anticyclone had curved to the north-eastward, and it will be seen from the Chart (Plate I.) that the typhoon made a similar change and increased its rate of motion to thirty miles an hour. In front of the depression the rainfall was very heavy, the Japanese reports showing 1·34 in. at Wakayama; 4·32 ins. at Tokei; and 2·56 ins. at Nobiru. On the southern side the *Samuel D. Carleton*, in 19° N, 130° E, had a Westerly gale, with a rapidly rising barometer, lightning and heavy rain. The German brig *August* became a total wreck on the Pescadores. The s.s. *Coptic* and the s.s. *Tanais*, going in opposite directions along the southern coast of Japan, experienced the strongest wind from North-east, force 8 and 9 respectively.

Early on the morning of the 2nd, however, the s.s. *Tanais*, going towards Yokohama, felt the full force of the typhoon. Until 3.30 a.m. the wind was light to moderate, but the barometer was down to 28·7 ins. At 3.45 a.m., in 33°26′ N, 137°45′ E, the wind was North-west, force 6, and five minutes later a hurricane from North-west burst upon the ship and lasted till 5 a.m., with torrents of rain. At the Tokei Observatory the lowest barometer,

28·88 ins., was at 7 a.m., the direction and force of wind doubtful; at 4 a.m. it was South-east strong, and at 3 p.m. North-north-west light. The whole of Japan was under the influence of a Northerly to North-westerly gale. Heavy rain fell in the northern districts, but west of Tokei, *i.e.* in the rear of the centre, it had ceased entirely. The anticyclone changing its course to the South-east, the typhoon passed along the eastern coast of Japan at the rate of thirty-three miles an hour. From near Shanghai the anticyclone moved east to Japan by the 3rd, the disturbance at the same time increasing its rate of progression to nearly fifty-one miles an hour—the maximum rate during its long journey. At noon (Greenwich) of the 3rd the centre was in 50° N, 174° E. Between the 2nd and 3rd the disturbance seems to have joined the one already alluded to as the Washington "Number XXVI.," which had made but slow progress because of a large anticyclone lying across its path to the east and north-east, forming a more effective barrier to the advance of a depression than a range of high mountains. The data in this high latitude being very meagre, I applied to the Chief Signal Officer at Washington for additional observations, with the result that I was able to prepare two daily charts from observations made at different stations—those from the nineteen stations supplied from Washington being for about 4 a.m. Greenwich time. By combining the two charts very satisfactory positions have been obtained.

That the area was still a very large one is shown by the fact that on the 2nd H.M.S. *Sappho*, in harbour at Honolulu, observed a change in the direction of upper clouds from South-east to West, with rain, the wind recorded by ships north and south of the Sandwich group being South-east. On the 3rd, the upper clouds were still from West at Honolulu, while winds of gale force were being experienced from all quarters between 30° to 58° N, and 167° E to 152° W,—a diameter of about 1,800 miles; the German ship *Adolph*, in 30° N, 155° W, 500 miles north of Honolulu, having a change of wind from South-east 3 to South 8, and afterwards to force 9, with heavy rain and lightning, the barometer falling to 29·73 ins.

So far the track resembles that laid down by Redfield for the Mississippi cyclone of October, 1854, in his Paper "On the Cyclones or Typhoons of the North Pacific Ocean, with a chart showing their courses of progression."[1] Redfield states that he had followed the typhoon for more than 4,000 nautical miles, and to do this he used the observations of only four ships, two of these being in company.

October 4th finds the progress of the disturbance suddenly checked, its rate being reduced to fourteen miles an hour; the cause of this being apparently the presence of the anticyclone some distance to the north-east. The area under the influence of gales was not so large on the 4th, the wind having moderated over the Behring Sea and the Aleutian Archipelago. Gales continued on the southern side, the s.s. *City of Tokei* experiencing a hurricane from West-north-west, in 35° N, 168° E; the s.s. *Gaelic*, in 37° N,

[1] *American Journal of Science and Arts*, Vol. xxiv. July 1857.

150° W, running into a South-west gale, with squalls, rain, and lightning; the *Adolph*, in 31° N, 152° W, had a West-south-west gale with rain and lightning. At Honolulu the upper clouds were now from North-west.

From the 4th till the 9th the depression remained in the neighbourhood of the Alaska Peninsula, the winds on the whole not being so violent. The anticyclone since the 2nd had kept on an Easterly course across the Pacific, and passing the meridian of the cyclone on the 7th, it entered the Western States of America on the 9th.

The cyclone having attained its highest latitude in the Pacific on the 6th and 7th, commenced to turn towards the south-east. The observations at Fort Rae show the anticyclone to be gradually leaving the neighbourhood, and the disturbance, which had moved at a rate of about 4½ miles an hour on the 8th, increased its speed to 6 miles on the 9th, and the next day to 35½ miles an hour, its position on the 10th being in about 51° N, 129° W. Heavy South-west and South-east gales were felt along the coasts of Oregon and Vancouver Island. At Portland there were hail and thunderstorms, the rainfall amounting to 2·93 ins. for the day. The cyclone had now reached the American continent, having travelled across the Pacific at an average rate of seventeen miles an hour.

The remainder of the track is taken from the North Atlantic Weather Charts. The Rocky Mountain Range does not appear to have been an obstacle in the path of the storm. According to the *Monthly Weather Review* of the Chief Signal Officer for October, 1882, a disturbance, which is the one we are following, No. VII. in the *Review*, is supposed to have "formed in Western Nebraska on the 11th, and pursued an erratic course. At first the movement was to the North-east, changing to the North-west, and recurving on the 12th west of Manitoba; after this, its course was about East-south-east. On the morning of the 13th the centre was north of Lake Superior. During the afternoon the course was again changed. It now began to move toward the north-east, and passed the limits of observation. At nearly every station in the Upper Lake region, the wind reached a velocity of more than twenty-five miles an hour. Rain fell during its passage in Montana, Dakota, the Missouri and Mississippi valleys, and the Lake region." The average rate of progress while under observation is stated to be 36·9 miles an hour. My calculations give 35·4 miles an hour between the 9th and 10th in the Pacific, and 36·7 miles an hour between the 10th and 11th, when it was entering the United States. The erratic course mentioned by the Chief Signal Officer is not shown on my track chart.

The maximum wind force recorded on the 11th was fifty-one miles an hour from West at Umatilla in Oregon. Proceeding east we find on the 12th that the maximum wind was fifty-four miles an hour from West at Eagle Rock, Idaho. At St. Paul, Minnesota, the State Armoury was blown down by a wind of forty-eight miles an hour. Heavy rain marked the progress of the storm, considerable damage being occasioned by the floods over an extensive area.

Continuing the north-easterly track out of the States the depression

crossed Hudson's Bay to the northern part of Labrador by the 14th, the rate of progress for the day being thirty-two miles an hour. On the 15th, in Davis Strait it attained the highest latitude (61½° N) reached during its course. Changing the direction to South of East, it was at the southern point of Greenland on the 16th, and continuing its south-easterly course to 55° N, 27° W, on the 18th, it was joined after a journey of close upon 10,000 nautical miles, at an average rate of something over eighteen miles per hour, by a disturbance which seems to have formed about October 9th in 22° N, 48° W. At 2 a.m. on the 10th, the ss. *American*, in 22°40′ N, 47°30′ W, ran into a heavy gale, with violent squalls, heavy rain, lightning, and a high dangerous sea.

The Atlantic high pressure area being well on the eastern side of the ocean, and a separate high area existing on the American side, the new depression was able to travel nearly north-east, slowly at first, but as it neared the other cyclone it increased its rate to about twenty-three miles an hour on the 17th and 18th.

In the great storm of September 1st, 1883, an account of which, by Mr. C. Harding, appeared in the *Quarterly Journal*,[1] the junction off the American coast of the two branches of a disturbance, one from the Western States, the other from the West Indies, was followed by a considerable acceleration of speed, the gale reaching our western coasts two days after the centre had passed Cape Breton. In the present case, the combining of two disturbances resulted in the direct contrary to this, for we find the centre located in about 60° N, 20° W, for a whole week (October 19 to 25), the area being very extensive, the isobar of 29·9 ins. on some days enclosing an elongated space of about 3,000 miles by 2,000 miles. Violent gales were felt for a considerable distance, over 1,000 miles, from the centre. As early as the morning of the 18th the *Daily Weather Report* shows the existence of the disturbance, although the centre was then 800 miles from the Irish Coast. The cessation of progressive movement must be attributed, I think, to a very large Anticyclone over Russia, Scandinavia, and northwards, the readings at the centre being about 30·8 ins. The original anticyclone from the Pacific now became merged in the Atlantic anticyclone, and was stationary in about 35° N, 35° W.

It was during this period of rest that the sharp storm of October 24th originated. I have examined the records of many ships over a large area west and south-west of the British Islands, but find nothing to justify our supposing that the storm had any existence until late on the night of the 23rd. At 9 p.m. the barque *Earl Granville* was in a calm with the North-west swell going down, in 48°30′ N, 9°40′ W. The *Lucia*, in 46°15′ N, 8°30′ W, at 1 a.m. had a sudden shift of wind from South-south-west to West by South. The barquentine *Gladstone*, in 47°45′ N, 7°25′ W, at midnight had an increase of West-south-west wind from force 9 to 11, and two hours later it suddenly shifted to North-north-west with heavy rain. The barque *Lycka Till*, in 49°6′ N, 8°20′ W, at 2 p.m., 23rd, reported the heavy Westerly gale decreasing, and

[1] Vol. X. p. 7.

at 4 a.m. 24th, in 49°20′ N, 7° W, the wind was North 2. The brig *Okenbury*, at midnight in 48°50′ N, 6°45′ W, reported that the wind lulled and suddenly shifted from South-south-west to North-north-east, subsequently going through North into West-north-west, the barometer at midnight being 29·23 ins. The s.s. *Drummond Castle*, at 2.30 a.m. in 47°8′ N, 6°55′ W, had a shift of wind from South-south-west to West-north-west 8, barometer 29·26 ins. West of the Channel these are the only records of changes since noon of the 23rd. At Falmouth Observatory the barometer began to fall about 10 p.m. when it stood at 29·6 ins., and reached its lowest point, 29·22 ins., at 6 a.m. 24th, being a fall of 0·38 in. in eight hours. The change of wind from South-west-by-South to North-by-West took place between 2 a.m. and 3 a.m., more than three hours before the time of lowest barometer. At the earliest, therefore, no prediction of an approaching storm could have been issued from the Meteorological Office before 3 a.m. of the 24th, and shortly after this hour the tempest was raging over the Channel and the French coast. The *Daily Weather Report* shows that at 8 a.m. Hurst Castle was the only station on the northern side of the Channel which recorded wind of gale force, on the southern side heavy gales were general. In the Channel the ship *Milo*, at 4 a.m., in 50° N, 3°50′ W, recorded "commenced strong gale;" at 8 a.m. in 50°20′ N, 2°45′ W, a whole gale from South-east was raging, and an hour later it veered to West and blew with terrific violence. The s.s. *Teniers*, at 6.20 a.m. in 49°50′ N, 3°40′ W, felt the commencement of a moderate East gale, and at 8.30 a.m. in 50° N, 3°15′ W, it changed to a strong gale from West-north-west. The *Lilian*, further east, had a hurricane from North-east, changing to West. By noon the storm was very severe from West and South as far up as the Downs.[1] The track followed by this disturbance is clearly shown on the *Daily Weather Reports*, and I need not repeat it here.

No sooner had the secondary system made a path up the English Channel into the North Sea, than the primary prepared to follow it. Starting towards the south-east at a rate of nearly eight miles an hour between the 25th and 26th, it increased it to nearly thirty-seven miles an hour next day, and on the morning of the 27th we find it near Rochefort, on the *Daily Weather Report*, the lowest barometer I have discovered for the whole track being 28·32 ins. this day. Its advance is marked, as in Japan and America, by heavy rain in all parts of Western Europe, the fall exceeding an inch in twenty-four hours at many stations, and the amount being nearly 4 inches in some localities. Fortunately for England the centre lay well to the south, for although the damages by floods and shipping disasters near home were serious, they are not to be compared with the havoc wrought over Southern Europe. Such was the extensive area covered by the storm that Sicily and Northern Africa felt the full force of it. Shipping casualties with loss of life occurred all along the Spanish and French Mediterranean coasts. In Algiers and neighbourhood

[1] In the *Proceedings of the Royal Institution*, Vol. VII. pp. 42, 43, Mr. Scott alludes to a gale which wrecked the *Royal Adelaide* on the Chesil Bank, November 22nd, 1872, and drove the *Inverness*, hove-to, from the Lizard to the Casquets. In the suddenness of its arrival this seems to be a parallel case to that of October 24th, 1882.

the rainfall for twenty-four hours amounted to 3 inches. Continental reports, from Portugal to Austria, show how general was the heavy downpour, the Italian Station of Domodossola registering 3·72 ins. in one day. The Swiss village of Grindelwald was reported to be "destroyed by the hurricane." In Austria alone the damage caused by the inundations cannot have been less than two millions sterling, the districts of Carinthia and the Tyrol being the principal sufferers. Looking at all the facts, it may be generally accepted that this typhoon was the principal contributor in making the month of October 1882 the most disastrous within living memory.

Immediately after reaching the French coast on the 27th the storm turned towards the north-east at a moderate rate, and slowly filling up it passed through France and the Netherlands to Denmark; thence curving to west of north it crossed the South of Norway, and by the morning of the 31st we find it a little east of the Shetlands, inclined to pass out into the Atlantic; but another large depression of superior energy, approaching our western coasts, apparently forced it eastwards again. At 8 a.m. on November 1st it is found crossing the southern part of Sweden, and by noon it had reached Gothland in the Baltic, where, after the very long journey of 14,000 nautical miles, it quietly disappeared.

The typhoon has thus been traced during an existence of thirty-six days, its average rate of progress throughout the journey being about sixteen miles an hour, the maximum rate in the Pacific being fifty-one miles an hour, while over the American continent and also over the Atlantic the maximum was thirty-seven miles an hour. Both over the Pacific and over the Atlantic the advance of the disturbance was considerably checked by anticyclonic areas existing across its direct path.

Until quite recently most persons have viewed rather unfavourably the idea that storms could reach this country from even the comparatively short distance of the Eastern Coast of America, and I cannot hope therefore that this, the first endeavour to trace a typhoon from its birth in the neighbourhood of the Philippine Islands to its death in the Baltic, will be immediately accepted as conclusive. I think there need be no doubt that many of our gales reach us from the Pacific, some travelling across the United States, others across Canada and even more northern regions. The storm of September 1st, 1883, has been shown to have come to Europe from the North-western States of America; going a step further, an article by Professor Loomis in the *American Journal of Science and Art*, Vol. VIII. July 1874, proves that atmospheric changes originating on the western coast of America are not retarded in their movement to the eastward by the Rocky Mountain Range—in fact depressions from the Pacific have not only crossed this high range, but have continued their course across the American continent and out into the Atlantic Ocean. In this Professor Loomis is supported by the track charts published by the Chief Signal Office, those for October and November 1881 giving the path of a disturbance which was first observed in the Sea of Okhotsk on October 15th, and after crossing the Pacific, on an erratic course, passed through Alaska, north of 60° N, to Manitoba by the 31st. Another disturbance

coming up from Texas, the two combined, and on November 5th passed into Labrador beyond the area of observations.

The typhoon of the end of September 1882 has afforded me the opportunity of still further extending our knowledge as to the possible duration of atmospheric disturbances.

Plate I., in addition to the track chart, shows the distribution of pressure and wind over the North Pacific Ocean for the fifteen days, September 26th to October 10th, when the storm entered Oregon and came within the area of the Meteorological Office Charts. The daily charts are necessarily very small, but there will be no difficulty in following the changes from day to day. With the exception of the wind at several of the Alaska Stations the data represented are for Greenwich Noon. An explanation of the Charts is given in the space following that for October 10th. The charts are the most complete that have hitherto been prepared for the same area; but I shall only refer to the fact that within the short period of fifteen days no less than three typhoons are shown: the first, off the south-east of Japan on September 26th, had been some days coming up from the Tropics, and travelled to Behring Sea, where, as already stated, it was joined by the second one, which followed in a very similar track. The third is seen towards the end of the period moving very slowly northwards on the edge of the Tropics, and on October 10th had developed into a fearful hurricane. Taking a more easterly course than the preceding ones, it was well out in the Pacific on the 11th.

NOTE.—The Chief Signal Officer, referring to this Paper, wrote on December 9th, 1885:—"Similar instances of probably continuous or nearly continuous tracks over the Pacific and Atlantic are already on record, but I know of none in which so much data has been brought to bear to elucidate the history of the storm. When storms are said to cross the Rocky Mountains or other plateaux, it is, I believe, understood that it is an abridgment of a fuller statement of the process by which a disturbance on one side gives rise to a disturbance on the other without the experience of an actual storm on the plateau. Barometric and sometimes thermometric disturbances are apparently thus propagated without special rainfall or wind on the higher levels, but the subject is still in need of further elucidation."

DISCUSSION.

Mr. LAUGHTON said there was one important point in the Paper with which he could not agree. He refused to accept the readings of the barometer as shown over the Rocky Mountain district: to his mind they were pure fiction. No real evidence was adduced to show that storms ever crossed these mountains, and he once again entered a protest against utterly uncertain reductions being put forward as such evidence.

Mr. ARCHIBALD said he entirely differed from Mr. Laughton regarding the impossibility of storms crossing a range like the Rocky Mountains, both on theoretical and practical grounds. He would not here discuss the theoretical grounds, but he had noticed that Prof. Loomis, in his recent "Contributions to Meteorology," had examined several cases of storms advancing across America from the Pacific, and it was absurd to suppose that all these could have originated

on the eastern side of the Rocky Mountains. He hoped there would be more Papers forthcoming like the present one of Mr. Harries, which he thought dealt with the subject on a scale commensurate with that on which such phenomena operated. We should soon perhaps be able to trace a storm right round the world, and recognise it as an old acquaintance when it re-appeared.

Mr. C. HARDING said that Prof. Loomis in one of his works attributed a common cause of storms which crossed the United States to the Rocky Mountains. The weather charts issued by the U. S. Signal Service certainly showed that storms often crossed these mountains. He had examined the charts which were used by Mr. Harries, and he could quite confirm the track as shown by him. It was a frequent experience with those who worked at charts on this scale, to find several depressions merging into one, and in fact the eccentricities of storm-systems were not to be accounted for, two or three merging on some occasions and single systems breaking up on others. He had made a careful examination of the International Charts of the U. S. Signal Service for some time back, and had only been able to find two tracks which at all compared with that now shown by Mr. Harries. On March 3rd, 1878, a storm-centre was situated on the coast of Oregon; it was subsequently tracked across the United States and the Atlantic, over the Mediterranean, Europe and Asia, and was finally lost in the Pacific on March 28th, within about 2,000 miles of where it first started. The second instance was a storm which was first shown close to the Islands of Japan on November 14th, 1878, and subsequently tracked across the Pacific and the United States, and finally lost to the north of Iceland on November 29th.

CAPT. TOYNBEE said he was surprised at the amount of material which Mr. Harries had collected for the Pacific, because as a rule meteorological data for that ocean were very scarce. With respect to Mr. Laughton's remarks, he reminded him that even if the barometer values were incorrect, the circulation of the wind would show the existence of a storm-system. This Paper clearly shows one of the difficulties which forecasters of weather have to contend with, viz. that storms sometimes traverse great distances in a short space of time, and on other occasions remain stationary for several days together. He hoped that the synchronous Charts of the North Atlantic which are being prepared by the Meteorological Office will supply scientific men with such a large amount of reliable data that they will be able to settle the following questions:—(1) As to the cause of the formation of cyclonic systems. (2) As to the process by which they change their positions. (3) As to the reason why they move in certain tracks. (4) As to why they sometimes stand still, at others move slowly, and at others quickly.

Mr. GASTER reminded the Fellows that severe comments were passed at the end of 1882, in the House of Lords and elsewhere, on the fact that the storm of October 24th had not been warned for by the Meteorological Office at 6 p.m. on the 23rd, and remarked that it was gratifying to find that the storm was not even in existence at the time when warnings could have been issued.

Mr. HARRIES, in reply, said regarding Mr. Laughton's remarks, that the actual values of the individual barometer readings referred to was not a very important matter, seeing that observations over an extensive locality reduced to sea-level on a uniform system showed areas of high or low pressure, as the case may be, in complete sympathy with observations at low level stations. Although the Chief Signal Officer in his report gave the origin of the storm as in Nebraska, he has in the International Track Chart given it as having crossed the Rocky Mountains from the Pacific. With respect to the doubt expressed as to the coalescence of the two disturbances in Mid-Atlantic, without even considering the wind changes, it seems in the highest degree improbable, when two areas are approaching and the barometer in each equally low, as in the Pacific, October 2nd, and Atlantic, October 17th, that one of them should suddenly disappear without in any way influencing the survivor. The tracks mentioned by Mr. Harding are rendered extremely doubtful from the fact that in 1878 there were no sea observations over the North Pacific, and there were no records from the interior of Africa. The track which has just been placed before the Society is, therefore, the longest that has been followed day by day throughout its continuance. He then referred to his having connected the birth of this typhoon with the anticyclone from Asia, and said that quite recently both Dr. Doberck of Hong Kong, and Padre Viñes of Havana, agreed in giving a rising barometer as an indication of the formation of tropical cyclones.

Notes as to the Principle and Working of Jordan's Improved Photographic Sunshine Recorder. By James B. Jordan and Frederic Gaster, F.R.Met.Soc.

[Read November 18th, 1885.]

The value of an automatic recorder of bright sunshine has for some time past been fully recognised by all leading meteorologists, and the public interest in the construction and use of such instruments appears to be increasing. But although it is a comparatively recent thing for Sunshine Recorders to have been placed in several parts of our Islands, the importance of the subject was sufficiently recognised, more than thirty years ago, to induce Mr. J. Campbell, of Islay, to construct an instrument the general principle of which has served as a basis for all the "burning" recorders now in use. At a much earlier date than this, however, in 1838, an automatic Daylight or Sunlight Recorder had been invented and constructed by Mr. T. B. Jordan, who wrote and published an account of his invention in the *Sixth Annual Report of the Royal Cornwall Polytechnic Society*, p. 185. A few words as to this arrangement will be useful.

The instrument consisted of two metal cylinders, one revolving on the other. The inner cylinder was fixed, and carried on its outer surface a sheet of sensitised photographic paper. The outer one revolved (by clockwork) once in twenty-four hours, and was perforated by an opening which was kept constantly directed towards the sun, whose rays thus acted on and discoloured the paper whenever his face was unobscured. When, however, the sky was cloudy, the paper was less deeply tinged by the ordinary (diffused) daylight, and in this way the varying intensity of the different parts of the curve gave an approximate record of the changes taking place in the brightness of the day. By revolving on a screw the outer cylinder altered its position slightly from day to day, and in this manner a week's record could be obtained on one sheet.

A second instrument was proposed by the same gentleman later on, by which a more precise measure of the intensity of the daylight was furnished by the instrument itself. Still more recently, experiments were made by fixing to the hour hand of an ordinary American clock a disc of sensitised paper. This revolved once daily beneath a metal cover in which a hole was pierced. Through this hole the light rays passed to the paper disc, producing a trace on its surface varying in tone with the intensity of the light prevailing from one hour to another. Owing, however, to the imperfect condition of the science of photography at that date, as well as to other reasons, the instruments did not receive the attention they deserved, in addition to which the employment of clockwork in an instrument which must of necessity be so long fully exposed to all changes in the weather, made it either expensive or liable to irregularity of action.

Thus matters remained until in 1854 Mr. Campbell constructed his Sunshine Recorder, consisting of a burning lens (a glass ball filled with water)

placed in a wooden bowl, the radius of which was equal to the focal length of the lens. This was exposed freely to the solar rays, which burned the mahogany into a series of rugged furrows. Each bowl was exposed for six months at a time, and consequently furnished a rough record of the burning energy of the sun during that period. The water globe was soon replaced by a glass ball. The instrument was kept working in Whitehall for several years, and the bowls are now in the possession of the Meteorological Office.

On the instrument coming into the hands of the Meteorological Council, a number of improvements were made in it, mainly by Mr. Scott and Mr. Lecky. A brass frame with a strip of cardboard, to be renewed daily, and marked with hours and half-hours, took the place of the wooden bowl. Finally a carefully constructed frame was designed by Professor Stokes, so that the variations in the sun's declination could be duly allowed for. These improvements resulted in the issue of the "Bright Sunshine Recorder" now in use by the Meteorological Office in many parts of the British Isles, and the records of which promise to be of great value to meteorologists and others. Numerous modifications of the frame and other mountings of the instrument have since been proposed, all more or less admirable for their purpose, but in all of them the essential principle is the same. Let us, however, observe one feature common to all: the instruments are no longer sunlight or daylight recorders, but recorders of bright sunshine—of sunshine the heat rays of which are sufficient to burn or scorch, by means of a certain lens, a piece of specially prepared cardboard. Here we have a definition of what is now termed "Bright Sunshine."

There were, however, two matters which soon forced themselves on the notice of the bulk of Meteorologists, viz. (1) The new instruments were too expensive to come into very general use; and (2) a little haze, or a film of cirrus cloud coming between the sun and the recorder was sufficient to stop the burning or scorching of the card, although the sun might be shining with considerable strength, and presumably exercising a great effect on the health and spirits of animals, and possibly on the life of plants also.

It was in order to remedy this state of things that the new (photographic) recorder, the subject of this paper, was designed by Mr. James B. Jordan, of the Home Office. The form in which the instrument first appeared, and in which it was exhibited at the Meeting of the Society in March 1885, proved somewhat inconvenient, and was accordingly modified as shown in the accompanying figure (Fig. I. p. 23).

It consists of a cylindrical dark chamber, on the inside of which is placed a prepared chart of photographic paper. The direct rays of sunlight are admitted into this chamber through small apertures; they are received on the sensitised paper chart, and, travelling over it by reason of the earth's rotation, leave a distinct trace of chemical action whenever the light is of sufficient intensity to show a definite shadow on a sundial. The depth of tone of the trace varies greatly with the intensity of the light, and thus affords (approximately) a record as to the brightness of the sunshine, as well as its duration. This is done to some extent by the "burning" recorder also, but

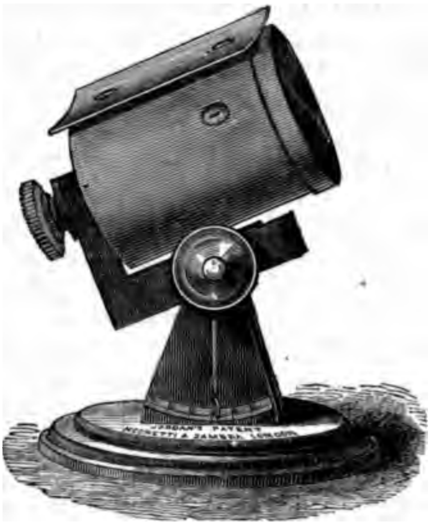


FIG. I.

in the new instrument the sun will continue marking, sometimes for hours together, when in the old one it has ceased to do so, owing to the presence of the thin clouds or haze already referred to. The cylinder is mounted on a suitable stand, having a simple means of adjustment, to admit of its being used in any latitude. Its adjustment to the true meridian is equally simple, as the upper portion of the frame turns on the lower by means of a central pivot. The charts are obtainable ready for use. The record is at once visible, needing no "developing," and can be "fixed" by simply immersing the chart in cold water for about ten minutes with its face downwards.

The instrument has now been in use for several months, and answers the purposes for which it was constructed.

It must be clearly understood, that there is no antagonism between the burning and the photographic recorder. The one registers the heat rays of a certain intensity, the other the actinic rays, so that in some respects the record of one instrument may be looked on as the complement of that of the other. Appended is a Table, giving the daily and aggregate values for the sunshine as registered by the two instruments during one month, the two instruments being side by side. From these we see that the photographic recorder registered about 11 per cent. more sunshine than its companion; but this is mentioned with a view to prove that the new instrument does its work well, rather than to suggest that there is any defect in the burning recorder when well made. Defects in construction are of course too common in most meteorological instruments, the results of which are often serious; but to remedy this the optician or maker must be appealed to. It may be assumed, however, that the simpler the instrument is the less liable will it be to such defects.

One or two remarks must be offered as to some objections which have been made to this form of Recorder.

SUNSHINE OBSERVATIONS TAKEN AT STAINES.

1885.	Burning Instrument. Hours recorded.						Photographic Instrument. Hours recorded.						Diff.	
	Before Noon.		After Noon.		Total.		Before Noon.		After Noon.		Total.			
May	h.	m.	h.	m.	h.	m.	h.	m.	h.	m.	h.	m.	h.	m.
10	1	40	2	55	4	35	1	40	2	55	4	35		0
11	4	20	3	40	8	0	4	30	3	30	8	0		0
12	5	30	5	30	11	0	6	20	5	25	11	45	+	45
[1]13	4	40	2	40	7	20	5	20	5	20	10	40	+3	20
14	..		..		..		..		..		..		..	
15	4	30	2	30	7	0	5	0	2	45	7	45	+	45
16	*		*		..		4	25	3	30	7	55	..	
17	3	20	1	20	4	40	3	40	1	50	5	30	+	50
18	4	15	2	15	6	30	4	45	2	15	7	0	+	30
19	3	0	1	0	4	0	4	0	2	0	6	0	+2	0
[2]20	0	0	0	15	0	15	1	10	0	35	1	45	+1	30
[3]21	2	50	3	45	6	35	4	20	4	0	8	20	+1	45
[4]22	0	0	2	10	2	10	0		2	30	2	30	+	20
23	3	45	4	50	8	35	3	50	5	0	8	50	+	15
24	5	50	5	40	11	30	5	50	6	0	11	50	+	20
25	0		0		0		0		0		0		..	
26	0	8	1	10	1	18	0	10	0	50	1	0	—	18
27	1	40	4	20	6	0	1	20	4	40	6	0		0
28	1	40	5	10	6	50	2	30	5	55	8	25	+1	35
29	2	30	6	0	8	30	3	0	6	20	9	20	+	50
30	2	50	1	20	4	10	2	55	1	55	4	50	+	40
31	6	0	3	30	9	30	6	25	3	25	9	50	+	20
June														
1	4	15	4	45	9	0	4	5	5	20	9	25	+	25
2	5	55	6	15	12	10	6	35	6	45	13	20	+1	10
3	6	10	6	15	12	25	6	35	6	30	13	5	+	40
4	6	0	6	35	12	35	6	40	6	50	13	30	+	55
5	5	45	4	50	10	35	6	30	5	30	12	0	+1	25
6	..		..		..		..		..		..		..	
7	3	30	1	0	4	30	3	40	1	0	4	40	+	10
[5]8	0		0		0		0		0		0		..	
9	0		0	3	0	3	0		1	0	1	0	+	57

[1] Hazy atmosphere throughout the day, increasing towards sunset.
[2] Very wet till 3 p m. [3] Very showery.
[4] Heavy rain till 2 p.m. [5] Very wet.
* Card shifted by wind.

(1.) It has been objected that it cannot register with uniform accuracy the intensity of the sunshine at all hours of the day, because as the beam of light enters the instrument at varying angles, a certain proportion of it is cut off by the sides of the aperture when the angle of incidence is small. This would certainly be the case were it not that the intensity of the light on the receiving surface is increased in corresponding proportion, by the surface affected being nearer to the aperture through which the beam enters as the angle of its entering decreases. The chemical intensity of the light is therefore truly recorded throughout the whole range.

(2.) As to the photographic method of recording sunshine generally—it has been said that a great objection to the system is the trouble of developing and fixing the results obtained. It is desirable, therefore, to point out that in Mr. Jordan's (as well as in Prof. McLeod's) instrument, the Cyanotype or Ferrocyanide process adopted requires no development whatever; the image is distinctly marked upon the chart, and can be registered immediately it is removed from the cylinder; and that it needs only to be "fixed" in order

to preserve the record for future reference. The fixing is readily done by placing the paper for a few minutes in cold water.

It remains only to say in conclusion, that the price of the new recorder is low, and to call attention to a few matters of importance to those who use it:—(1.) Keep the sensitised charts, before they are used, in the dark; (2.) See that they fit perfectly round the cylinder, and that the apertures are free from dirt; (3.) See that the instrument is on a level and firm base, and adjusted to the true meridian; (4.) Count up the hours of sunshine and group them according to their intensity before placing the charts in the water for fixing, as occasionally portions of the very faint traces may disappear during the operation; (5.) Leave the chart in the water when "fixing" it for about ten or fifteen minutes, placing its face downwards, and occasionally shaking it a little; (6.) Date the record with care.

Much credit is due to Messrs. Negretti and Zambra for the careful way in which they have carried out the details of the instrument and brought it to its present compact form.

DISCUSSION.

Mr. BAYARD exhibited the sunshine charts from a Jordan's recorder with which he had commenced registering in March 1884, and said that it would be seen that in some cases the traces had almost disappeared. He wished that a more sensitive paper could be used, as frequently the faint traces vanished when placed in water for fixing the record.

Mr. WHIPPLE remarked on the ingenuity of the instrument, and went on to explain the difference between the registrations of Jordan's and Stokes' or Campbell's sunshine recorder, the one registering rays at the blue end, the other at the red end of the solar spectrum. He thought it was very desirable that the two modes of registration should be kept distinct, as neither was in itself a perfect record of sunshine, one supplying what the other lacked.

Mr. LECKY agreed with Mr. Whipple as to the ingenuity displayed in the construction of the instrument, but thought that the registration of sunshine by photography was of very little use in meteorology.

Mr. SYMONS said he had had very little experience indeed in the use of sunshine recorders, but the question had lately been considered by the Council of the Royal Botanic Society, and the conclusion they came to was that, so far as botany was concerned, the actinic rays were the more important; they, however, decided upon recording both heat rays and actinic rays. He should like some one to say what degree above the horizon a sunshine recorder must be placed in order to record the sunshine as soon after sunrise as possible. Mr. Symons supported Mr. Whipple's caution as to confusing the two systems of recording; possibly it would be avoided by giving to the photographic method the title of "sunlight" recorder.

Mr. ELLIS remarked that record could not generally be obtained under an altitude of the sun of 5°, or at least that there should be no obstacles above this altitude. He was not prepared to say what this represented in time. (Subsequently Mr. Ellis stated that 5° represents about 40 minutes, more or less according to the time of year.)

The PRESIDENT (Mr. Scott) said that Mr. Dowson, at Geldeston, had obtained a record as early as twenty minutes after sunrise. Mr. W. E. Wilson, F.R.A.S., a friend of his in Ireland, had lately patented an instrument for the record of sun heat, which was extremely sensitive and apparently would rival Mr. Jordan's instrument in that particular.

Mr. GASTER said, in reply, that the matter referred to by Mr. Whipple had, he thought, been sufficiently dwelt upon in the paper; and that as to Mr. Lecky's objection, it would be necessary first to prove that the actinic rays in sunlight are of no importance before asking to have them neglected.

On the Influence of Forests upon Climate. By Dr. A. Woeikof, Hon.Mem.R.Met.Soc.

(Translated from *Petermann's Mittheilungen*, 1885, No. 3; and communicated by J. S. Harding, F.R.Met.Soc.)

[Read December 16th, 1885.]

The existence of any influence of forests upon climate has often been contested, and the question remained for a long time unsettled, because meteorologists were content to apply principles of too general a character. The first step towards a scientific investigation of the subject was the establishment of the Bavarian Forest Meteorological Stations, the results of which have been published by Professor Ebermayer. The excellent example of Bavaria was soon followed by Germany, France, Switzerland, Italy, and other countries. As a general result it was found that during the warmer season (1) the air and earth temperatures were lower in the forest than in contiguous woodless places; (2) their variations were less; and (3) the relative humidity was greater.

The following details, referring to the amounts of evaporation from April to September, are quoted as being of special importance :—

	In the Open.	In the Forest.	Percentages.
	Ins.	Ins.	
Eastern France	[1] 16·23	5·20	312
The Alsatian Mountains	13·19	6·26	211
Bavaria......................	14·85	6·22	239
Brandenburg	15·71	6·42	245
Eastern Prussia	9·93	4·73	210
The Silesian Mountains........	10·52	4·17	252

1 Note. The measures have been converted to their English equivalents, occasionally altering the round numbers employed by the Author. [*Trans.*]

It will be therefore seen that the evaporation from a free surface of water in the open was everywhere more than double, and even above three times that in the forest. In Bavaria, the evaporation from soil saturated with water was observed. This amounted in the same seven months to 16·07 ins. in the open, 6·26 ins. in the forest without dead leaves, and 2·44 ins. in the forest with them. This experiment shows that the evaporation in the open is 6½ times as much as in the forest with the covering of dead leaves. The influence of the forest on the diminution of evaporation from water and ground is so great that this cannot be explained by the lower temperature of the warmer months only, by greater humidity, or even by the shade: one influence which has hitherto been too little regarded is especially important in effecting this result, viz. protection from the wind afforded by the fact of the trees standing closely together. This last cause is probably more important in its effects than all the others put together.

The diminution in wind force which is caused by the presence of trees is well known, although we have unfortunately no numerical data with reference to it; but it could easily be investigated by the erection of anemometers. It follows also from the laws of Mechanics, that if this diminution

of the wind in forests is chiefly evident in the lower strata of the air below the tops of the trees, it cannot cease immediately above them, but owing to the so-called viscosity of the atmosphere, must extend to a considerable height, so that the motion of the air must be weakened up to five or even ten times the height of the trees. This indicates the extent of the favourable influence which forests must exert in maintaining the humidity existing in air or soil; and naturally the denser the forest and the higher the trees, the greater is this influence. But if this action is incontrovertible, the same cannot be said of the influence of forests upon rainfall, &c.; an influence which is as often asserted as it is denied. Hitherto the best observations giving comparative values and maintained for a sufficient length of time were those made in the neighbourhood of Nancy.

The three stations were situated as follows:—

A. Cinq Tranchées, about five miles west of Nancy, in the midst of great forests, 1,247 feet above sea-level, on a plateau of Lower Oolite rocks; the rain-gauge being placed in a meadow of some acres in extent.

B. Belle-Fontaine, about four miles north-west of Nancy in a valley on the border of the forests, 787 feet above sea-level. The rain-gauge is here placed in a nursery garden.

C. Amance, about six miles north-east of Nancy, on a hill of Lower Oolite, 1,247 feet above sea-level. The district is almost woodless, fields being predominant.

It will be seen that for A and C at least the height above sea-level and the rock formations are identical; the surrounding country is not mountainous but only hilly.

The following are the amounts of rainfall, &c. deduced from the mean of seven years' observations:—

	Cinq Tranchées. Ins.	Amance. Ins.
February to April	6·26	5·87
May to July	7·36	6·50
August to October	7·60	6·18
November to January	8·40	6·97
Annual total	29·62	25·52

In eighty-four months there were sixty-three in which A had more rain than C. In two, the falls were equal, and there were only nineteen in which C had more rain than A. July 1872, and July and August 1875, have been excluded from the calculation, because the great difference shown in those months was probably due to violent showers; if these are included, we get the following annual sums, A = 30·21 ins., B = 27·29 ins., and C = 25·56 ins. The station B occupies an intermediate place between A and C. The observations indicate a considerable influence of forests on the increase of rainfall. It would seem that in winter the effect of forests upon rainfall ought to be unimportant in the climate of Central Europe,—the difference of temperature and humidity between forest and field being very small,

and the amount of vapour in the atmosphere inconsiderable. The observations, however, show that during this season the forest really receives much more rainfall, &c. this being accounted for by the following facts:—(1.) In winter the clouds being at a lower level than at other seasons, the obstruction caused by the forest to the motion of the air must then considerably affect their motion; the air will consequently be forced upwards, and at a time of great relative humidity a small change of level suffices to produce condensation of the vapour. (2.) In winter damp West winds are more frequent, and the rainfall is of longer duration; hence the greater importance of forest influence at that season. In the spring and early summer the effect of forests upon the increase of rainfall is much diminished, because at these seasons there is considerable evaporation from the surfaces of fields and meadows; probably more water evaporates then from a given extent of field than from an equal surface of forest, taking into account the evaporation both from crops and soil. Towards the end of summer and the beginning of autumn the soil of the fields is considerably dried up, corn is ripe and evaporates but little, while the surfaces of the leaves in the forests still evaporate freely. Conditions then are more favourable to an increased humidity of the air in the forests, and hence to more copious and frequent rainfalls. There are other modes of condensation of vapour for which forests are especially favourable. In winter large quantities of hoar frost collect upon coniferous trees, which by the action of the wind falls, increasing the amount of snow on the ground. In warm and moist climates, especially in the tropics, dew collects so freely on the surface of leaves as to fall in large drops and wet the ground. In this manner a considerable amount of the water evaporated during the day returns again to the earth in the form of dew the following night.

The question now arises whether similar instances of the influence of forests are exhibited in other climates. Since no observations taken at forest meteorological stations in low latitudes were available, the question must be put otherwise:—Have great forest systems such an influence on the climate, that their effect may or may not be similarly recognisable in observations taken outside of forest limits? India affords good examples of this. It should be remarked here, that the diminution of temperature as we proceed northwards takes place very slowly, for example, it only amounts to about 0°·14 F. per 1° of latitude between lats. 19°—31°. It must also be observed that in Northern India the months April—June have justly been called the hot season and are extremely dry over a great part of the country, for the heavy falls of rain only commence about the end of June. The heat and drought are most intense in the interior, being naturally moderated on the coasts by the proximity of the sea. Between lats. 23°—27° in Northern India districts exist with scarcely any forests, such as the greater part of Bengal, the North-west Provinces, and Oude. There are also thickly wooded countries, Assam (the central district of the Brahmapootra), Silhet, Cachar, and the region east of the lower course of the Brahmapootra. It will be seen from the table given on p. 30 that in the timbered districts of Northern India, even at some distance from the sea-coast, (1.) the hot period

in April to June disappears, so that the temperature rises uninterruptedly from January to July. (2.) The mean temperature of the months April to June is from 7° to 11° lower than in the unwooded regions equally remote from the sea, a difference observed nowhere else on the globe between stations so close together and having no intervening mountains between them. (3.) The maxima differ even to a greater extent than the means, and are scarcely higher in the forest districts of Northern India than in Central and Southern Russia; whilst in the woodless parts of Northern India, even in close proximity to the sea, temperatures exceeding 104°, and frequently 113°, occur annually. (4.) The humidity of the air is great, especially in the densely wooded districts of Upper Assam (Sibsagar), which during April to June exceeds the mean relative humidity of woodless regions at an equal distance from the sea by 40 per cent. (5.) This may perhaps tend to explain the early commencement and gradual regular increase of rainfall in the timbered countries. To the westward of the district we find a sudden decrease of temperature in June or July, whilst after the prevalent winds of summer have set in, the rains keep off for a long time on account of the air being too hot and too dry for precipitation. (6.) In order to show that the relative humidity in Sibsagar is not high only in the rainy months, the means for December, which is almost rainless there, are also given. Yet the mean humidity is 82 per cent., against 60 per cent. in Patna, which lies much nearer to the sea-coast.

The Table requires no farther explanation. The figures are taken from the *Report on the Meteorology of India*, 1880, with the exception of the maxima, which have been calculated from the separate years 1877-80, as in these years the exposure of the thermometers was good and their corrections were known. The maxima almost always fall in the months April to July, and if, as seldom happens, they fall at other times, they differ but little from the maxima observed in those months.

It may be argued that the high humidity and the relatively low temperature in Upper Assam from April to June may be a consequence of the general climatic position, and not of the dense forests which exist there. This is only the case to a certain extent. Upper Assam is far distant from the hottest and driest parts of India; the Table points out that even the proximity of the sea moderates the heat less than do the forests (see Saugor Island). It should also be noted that Upper Assam has a position to the leeward of the damp South-west Monsoon; this must diminish the amount of rainfall and even give rise to Föhn winds. In fact, Sibsagar in June and July is warmer and drier than Goalpara. A glance at the map shows that the Khassia mountains lie to the South-west; on the slopes and summits of these the rainfall is the most copious known upon the Earth, and falls almost exclusively between May and October. As the wind rises over the mountains, before it descends into the valleys of the Central Brahmapootra, it must be relatively dry. These mountains therefore cut off the direct supply of moist air, allowing only a small arm of the moist Monsoon to penetrate the country indirectly from the West. There is scarcely any increase of rainfall as far as Sibsagar, on account of the ascent of the air, for the place is scarcely more than 360 feet

Latitude to nearest degree.	Place.	Distance from the Sea.	Mean Temperature. April.	May.	June.	July.	December.	Year.	Mean Max. April-July.
	TERRITORY WITHOUT FORESTS.	Miles.							
°			°	°	°	°	°	°	°
27	Agra	687	87·3	93·2	94·1	87·1	61·8	78·7	117·3
27	Lucknow	526	86·5	91·7	92·3	86·4	60·7	78·1	117·0
25	Allahabad	424	87·4	92·1	91·6	85·0	60·5	77·1	116·1
26	Patna	277	86·6	88·6	88·6	84·7	62·3	77·8	111·7
24	Berhampore	168	85·2	85·5	84·5	83·4	65·8	78·1	108·7
23	Burdwan	121	86·0	85·5	85·3	84·0	66·8	78·8	107·6
22	Saugor Island	On Sea	84·2	85·8	85·7	83·9	68·2	79·5	95·0
	FOREST TERRITORY.								
25	Silchar	183	78·1	80·0	81·7	81·9	65·7	75·6	98·1
26	Goalpara	265	77·6	78·5	80·2	81·4	64·9	74·9	97·2
27	Sibsagar	345	74·0	77·6	82·7	83·3	60·7	73·3	98·4

Latitude to nearest degree.	Place.	Relative Humidity. April.	May.	June.	July.	December.	Year.	Rainfall. April.	May.	June.	July.	December.	Year.
	TERRITORY WITHOUT FORESTS.	o/o	o/o	o/o	o/o	o/o	o/o	Ins.	Ins.	Ins.	Ins.	Ins.	Ins.
°													
27	Agra	31	34	40	69	54	50	0·17	0·71	2·85	9·13	0·26	25·46
27	Lucknow	38	44	51	73	60	58	0·15	0·79	4·41	10·85	0·42	37·91
25	Allahabad	36	42	50	78	69	62	0·16	0·33	4·24	12·03	0·12	37·91
26	Patna	38	51	62	78	59	60	0·30	1·46	6·55	10·19	0·13	41·04
24	Berhampore	60	68	79	85	69	72	2·11	4·58	9·97	10·56	0·09	56·37
23	Burdwan	60	68	78	84	66	71	2·64	4·75	10·02	12·05	0·14	57·83
22	Saugor Island	80	80	83	85	74	80	1·41	4·38	11·67	14·37	0·20	72·40
	FOREST TERRITORY.												
25	Silchar	72	77	83	84	72	76	12·13	14·47	19·15	21·23	0·50	117·11
26	Goalpara	68	77	87	86	73	75	6·32	12·48	25·94	17·97	0·30	95·26
27	Sibsagar	80	82	83	84	84	82	10·29	11·07	15·07	15·71	0·52	94·64

above sea-level, and sufficiently remote from the mountains on the north and east. A similar example of the moderation of the heat by extensive forests is found in South America, much nearer to the Equator than in India; unfortunately, however, few observations are available. The following Table represents the conditions prevailing in that region. The distance from the Atlantic is shown because the influence of the Pacific Ocean is quite cut off by the Andes and the territory of the Amazon. All the places are probably under 660 feet above the level of the sea.

In the accompanying table Iquitos is especially worthy of notice—situated almost under the Equator, very far from the sea on a plain scarcely 350 feet above the level of the sea and yet having an absolute maximum of 90°·3, the warmest month being but 78°·8. Every volume of travels (especially Bates's work, *The Naturalist in the Amazons*) testifies to the density of the forests and the luxuriance of vegetation in these countries. The rainfall also is

Place.	South Lat.	Distance from Atlantic.	Mean Temperature. Year.	Mean Temperature. Warmest month.	Absolute Max.	Relative Humidity.
	°	miles.	°	°	°	0/0
Pará	1½	62	80·6	81·9	..	..
Manáos	3	715	79·0	80·6	96·3	80
Iquitos	3½	1305	76·6	78·3	90·3	83
Pernambuco	8	on coast	78·3	80·8	89·1	72
San Antonio (on the River Madeira)	9	1087	78·8	80·6	..	..

especially large, 112 inches a year; and exceeds that observed any where else at a similar distance from the sea or mountain ranges. It is also remarkable that Pará, which is nearer the sea, has a higher temperature.

San Antonio, on the River Madeira, is somewhat warmer than Pernambuco, on the sea coast; but the following facts must be taken into consideration:—(1.) That there is much rock near the river Madeira, and therefore favourable conditions exist for the heating of the air by radiation from these rocks. (2.) At Pernambuco the East wind from the sea prevails, which cools down the air. On the other hand, the air is drier at Pernambuco than in the wooded districts of the interior. Table No. 2 shows that dense forests near the Equator cool the air as much as or even more than the sea does, and that high maxima do not occur where extensive forests exist. It has already been stated that this is due to evaporation from the leaves and to the diminution of the wind's force. In the first case, the effect of thick, low, vegetable growths is analogous: but (1) the diminution of the wind's force is inconsiderable, hence the humidity can more rapidly be carried away; (2) In the case of plants such as grasses, which are not deeply rooted, the moisture of the ground is soon exhausted, and they quickly wither if rain does not fall frequently; little evaporation then takes place, and the cooling effect is diminished.

Forests retain the water from rain or melting snow much better by the covering of dead leaves, mould and moss, and only allow a portion to run off superficially when large quantities of water fall; the remainder percolates gradually, and much of it is utilised in evaporation from the trees. Although forests, especially the dense luxurious forests of the tropics, cannot, of course, exist without a certain supply of water, yet the time when they receive it is of little import to them. A good instance of this is the Lencoran Forest, on the west coast of the Caspian Sea, where vegetation is more luxuriant than in any part of Europe; for a mass of climbing plants encircles the trees so that it is always humid in the forest, and yet here the rain curve is a subtropical one, very little rain falling in summer, but large quantities in autumn and winter. The water is stored up in the forest, so maintaining evaporation during the summer droughts.

In Upper Assam also, during the four months November to February, little rain falls, but the evaporation of the forests keeps the air damp. It

would appear that the influence of dense forests of warm regions upon rainfall is such that, if the general climatic conditions are opposed to rain little rain falls, even where those forests are extensive. This is the case when the wind is constantly descending, or blows from cooler and drier quarters,—as from November to February in Assam, when North-east winds prevail. If there is a strong wind from warmer and damper quarters, and especially if it has an ascending motion, the conditions are favourable for rain, whether forest, field or steppe predominate. Weather types are very far from being always so strongly defined. Frequently, in the vicinity of the Equator, the winds are variable or local; or calms prevail. Under such conditions dense forests must be favourable to rainfall, as offering an obstacle to the wind's movement, they cause the air to ascend; and since it is already damp, condensation ensues. With the same direction of wind there would be little or no rain in woodless regions. During calms and clear weather, after a long drought, the ascending current over forests is much more humid than that over unwooded districts where the ground is dried up, and vegetation withered. Here then are conditions again more favourable for rain production; in the former case even calms alone may cause rain with an ascending current; an example of this may be quoted in the case of the frequent afternoon thunderstorms in well-protected Alpine valleys. The correctness of the above remarks is proved by the frequent earlier commencement of rain in the tropical forests.

Attention has before been drawn to the humidity of the air and the relatively low maxima in forest districts of low latitudes. It must not be understood, however, that damp air is incompatible with high temperature. The climate of the Red Sea proves the contrary. There the relative humidity of the air is very great, with a mean temperature for several months of over 86°, whilst a temperature of 104° and upwards is sometimes observed. In forests the humidity is, however, chiefly derived from leaves, *i.e.* by a process by which heat is converted into work, hence the cooling effect which takes place. With regard to the question as to whether the influence of forests on the climatic conditions of their vicinity is also manifested in the western portion of the world,—in latitudes 38°—50° N,—let us select the temperature of July as being the warmest month. On the whole the temperature is lower on the shores of the Atlantic Ocean, and rises towards the interior of the continent. In the following tables only observations beyond forest limits have been taken, and in order to allow for the influence of latitude, it has been assumed that the temperature increases to the southward at the rate of 0°·9 F. (0°·5 C.) for each degree of latitude. For every 328 feet (100 metres) of altitude a correction of 1°·3 has been applied. The results are not reduced, however, to the sea-level, but to 656 feet above it. This lessens the reductions for the greater number of stations, and also diminishes the possible error.

Mean temperature of July reduced to 52° N latitude and to 656 feet above sea-level:—

	°		°
Valencia (Ireland)	57·6.	Orel & Kursk (Mean)	67·6.
Leipzig	62·6.	Poljänki (Ssaratow)	65·7.
Warsaw	64·8.	Orenburg	69·1.
Tschernigow	65·1.	Akmollinsk (Kirghiz steppe)	70·0.

There is here a rapid rise of temperature from the ocean to Central Germany and Poland, where it is partially interrupted. It is scarcely noticeable from Warsaw, as far as the district of the central Dnieper, on account of the numerous forests and marshes. It increases rapidly again to the Tschernosjem district of Central Russia with its almost uninterrupted fields, then falls more than 1°·8 in the great forests at the sources of the Ssura, to rise again in the steppes of Orenburg and Kirghiz.

Mean temperature of July reduced to 50° N latitude and 656 feet above sea-level:—

Guernsey	59°5.	Troppau	68°0.
Brussels	62·6.	Arvavaralja (N.W. Hungary)	64·2.
Würzburg	68·0.	Lemberg	65·5.
Promenhof (N.W. Bohemia)	64·4.	Kiew	66·2.
Prague	68·0.	Charkow	68·4.
Hochwald	63·7.	Ssemipalatinsk	72·7.

Again there is a rise of temperature from the ocean to the valley of the Main; then the great forest regions in the West and East of Bohemia cause a considerable fall; in the middle of that country it is again higher, and also in Austrian Silesia. In the densely wooded valleys of the Hungarian Carpathians it is much lower. In Eastern Gallicia, far from the Carpathians, the influence of the adjacent forests is so great that the temperature is lower than in the valley of the Main and in Central Bohemia. At Kiew it is still lower than in the above mentioned districts; for forests and marshes extend nearly to the town on the north-west and north-east sides. Even Charkow is little warmer than Prague. Great woods existed there even recently; but further to the east, where there are only steppes, it is much warmer.

Mean temperature of July, reduced to 48° N. latitude and 656 feet above sea-level:—

	°		°
Brest	62·2.	Bistritz (Transsylvania)	68·0.
Versailles	65·5.	Czernowitz	68·9.
Carlsruhe	66·6.	Ekaterinoslaw	71·6.
Vienna	67·8.	Lugan (S. Russian steppes)	72·5
Debreczin } Hungary	70·7.	Irgis (Kirghiz steppes)	75·6.
Rosenau } Hungary	68·9.		

The temperature increases from the Atlantic Ocean as far as the Pusztæ[1] of Hungary. But it is much lower in the forests in the east of this country; but the relatively low temperature of Czernowitz in the Bukowina is especially

[1] Steppes. In "Ogilvie" pronounced Poostæ.

remarkable. This place is a long way from the ocean and is separated from it by mountains, but near to the South Russian steppes and not separated from them by any obstacle, and yet July is considerably colder here than in the middle of Hungary. The surrounding beech forests are certainly one of the principal causes of this phenomenon. Further eastwards a great rise of temperature is observable from the Southern Russian steppes, where agriculture without irrigation is extensively carried on, as far as the Caspian steppes, on which it is no longer possible.

Mean temperature of July reduced to 46° N latitude and 656 feet above sea-level:—

		°			°
La Rochelle		66·7.	Orawicza	Mountains	67·5.
Milan		69·3.	Pojana Ruska	S.E. Hungary	67·8.
Trieste		72·7.	Odessa		71·2.
Zaghrab (Agram)		71·1.	Cherson		72·5.
Szegedin	Hungarian	71·6.	Astrakan		75·6.
Arad	Pusztæ	73·0.	Raimsk and Kasalinsk (Syr-Darja)		76·1.

The high temperatures of July at Trieste, on the sea-coast, are noteworthy. But it is well known the environs of the town are bare and sunburnt, and how strongly the sun heats the rocks. The temperature is lower in the highlands of Croatia, where large forests still exist. There is no doubt that in the interior of Servia and Bosnia the temperature in summer is lower still, owing to the same cause; while near the sea, where the surface is bare rock, the temperature reaches a higher point.[1]

Mean temperature reduced to 42° N latitude and 656 feet above sea-level:—

Oporto	67°·6.	Kutaïs	73°·0.
Rome	75·2.	Tiflis	78·8.
Ragusa	74·3.	Nukuss and Petroalexandrowsk (Amu-Darja)	80·2.
Poti	70·9.		

Here we see a relatively low temperature in the vicinity of the thick forests of Mingrelia (Poti), amounting to 3°·6 lower than on the shores of the Adria, in rocky Dalmatia.

From the position of Poti, situated much further in the interior of the continent, we should rather have expected a higher temperature. Even at

[1] In an appendix to the paper the author refers to Tables published in the *Oesterreichische Zeitschrift für Meteorologie*, 1885, No. 1, for these countries, which confirm his view in a remarkable manner. Reducing the Tables to latitude 44° and to 656 feet (200 metres) above sea-level (assuming as before a decrease of temperature of 0·9 F. (0·5 C.) for 1° of latitude and 1°·3 F. (0°·7 C.) for 328 feet (100 metres) of elevation), it was shown that (1) the temperature in summer in Bosnia was from 4°·5 to 8°·1 cooler than in the Herzegovina; and that (2) even on the Island of Lissa, where under the full influence of the Adriatic Sea the summer should be cooler, the temperature is more than 1°·8 higher than it is in Bosnia, which is separated from the sea by high mountains. Hence he concludes that Bosnia owes this relatively cool summer to her extensive forests.—*Translator.*

Kutaïs, remote from the sea, July is cooler than at the sea-shore in Dalmatia. Tiflis is warmer still; here we have an absence of forests not only in the valley, but also on the mountain slopes, rendering, generally, the valley abnormally hot. The places on the Amu-Darja, being situated in the plain, represent better the general conditions of the region. It is to be observed that here July is probably cooler than in the adjacent steppes, owing to irrigation.

Mean temperature of July reduced to 38° N latitude and 656 feet above sea-level:—

Lisbon	70°·5.	Smyrna	77°·9.
Campo Maior	76·3.	Lenkoran	74·7.
Palermo	76·5.	Krasnowodsk	82·0.
Athens	79·2.		

In Portugal, which is poor in forests, the temperature rises very rapidly towards the interior,—the ground is much heated during the almost rainless summer. The heat is still greater in stony Attica, notwithstanding the proximity of the sea. The case is different in Lenkoran, near which dense forests exist and greatly cool the air. On the contrary, on the eastern shore of the Caspian, owing to the desert of sand and stone, the temperature is very high.

If we take the temperatures of Lenkoran and Poti, that is, of two places in the vicinity of very thick luxuriant forests, without reducing them to 656 feet (200 metres), but reduce those of Lenkoran alone to latitude 42° N, we obtain a temperature of 75°·1, or 0°·4 more than the mean temperature of July at Poti.

The above considerations show that in the western portions of the Old World extensive forests materially influence the temperature of neighbouring localities, and that the normal increase of the temperature from the Atlantic Ocean towards the interior of the continent is not only interrupted by their agency, but that they cause the summer to be cooler in regions situated further in the interior than those nearer the sea.

Hence forests exert an influence on climate which does not cease at their borders, but is exerted over a greater or less district, according to the size, character and position of the forests. Hence it naturally follows that man, by clearing forests in one place and planting others in another, may considerably affect the climate. Many incline to the idea that, as forests increase precipitation, it would only be necessary to plant in order to remove deserts from the earth's surface. No person familiar with meteorological questions will, of course, assume such an extreme position. If the forest economises rainfall, stores it up for a long time, and even to a certain extent increases precipitation, many parts of our earth are nevertheless too dry to support trees, forest vegetation requiring much water. On the other hand, thin forests and such as consist of trees the leaf surface of which is of a waxy character, which diminishes evaporation, are certainly able to survive in drier climates than denser forests consisting of trees which evaporate

more freely; but the former have less effect in moderating heat and drought than the latter. On the other hand, the widespread opinion that no forests can exist where none existed at the time of the appearance of civilised man is open to doubt. The success of forest culture in the Steppes of Southern Russia, the Prairies of North America, and the Pampas of South America, sufficiently prove the untenability of this opinion. If afforestation has not hitherto assumed large dimensions, it has been rather as a matter of economy than of climate.

Other growths, such as corn, or the use of the land for pasture, &c. have been more remunerative to private individuals—human life being of but short duration as compared with that of trees.

If there be only a certain amount of rainfall, no matter at what time of the year it occurs, forests can flourish. Even long periods of drought are much less injurious to forests than they are to meadows and fields; and the impossibility of forest culture in a country is not due to the occurrence of rainless periods, provided that copious precipitation falls at other times.

DISCUSSION.

Mr. W. B. Tripp exhibited a coloured map of South Africa, showing the mean annual rainfall, based upon the figures published in the *Reports of the Cape Meteorological Commission*. He said that South Africa may be described as a Table land, approached on all sides from the coast, by successive terraces of hills. The Rainfall varied from about 2 ins. at the north-west boundary to some 50 or 60 ins. on Table Mountain, the Katberg, and other mountainous regions; the mean was greatest on the east coast, to the north-west it rose in Natal to over 40 ins. Local hills and forests modify the total fall very considerably over small areas. The total annual fall was, however, for the most part fairly distributed throughout the year: that at King William's Town, in the Eastern Province, where Mr. Tripp and others have kept meteorological records for some years, presenting the following characteristics. The extremes during the fifteen years succeeding 1868 were 15 ins. and 37 ins., and the average 26 ins. Of the average, about 9¼ ins. fell during the summer from January to March, and nearly 8 ins. in the spring from October to December, and about 4¼ ins. each in the autumn and winter. During a total of 283 days on which rain fell, from June 1880 to March 1883, as observed by Mr. Tripp, 70 ins. of rain were registered at the Botanical Gardens. Of this, 30·25 ins., taken on 242 days, were made up of falls of under 0·50 in. in twenty-four hours, 19·88 ins., on twenty-eight days, of from 0·50 in. to 1·0 in., and 19·87 ins., on thirteen days, of falls of 1 in. and over. On only one occasion did the fall reach 2 ins. in twenty-four hours; although there are on record falls greatly exceeding this amount, such are, however, rare. The annual distribution, of course, varies from the above results in other parts of the colony. The greater part of the country may now, in spite of some fragments of the original forests which still remain, be said to be practically devoid of trees. Mr. Tripp was of opinion that drought is not by any means the chief cause of this denudation, wholesale tree felling, without proper regulation, being a much more destructive agency. Nor is drought the only obstacle to re-afforesting, for in some parts the soil is too saline to permit of much successful tree planting; occasionally, however, it has been found practicable, after much perseverance, in such places to grow some species by penetrating through a saline surface soil to a deeper and purer stratum. Still there are many parts now denuded where there is good evidence to show that trees once were plentiful. The Cape Government has of late years made considerable efforts to preserve those portions of the forests which remain, as well as to re-afforest those parts which have been denuded of trees, and also to plant trees where their influence might be beneficial on various accounts. The Superintendent of Forests has given his opinion that by clothing the sides of the hills with trees, more especially from the Konisberg to the Compass Berg at the south, a very beneficial effect would be exercised on

the more inland regions known as the Karroo, and other portions of the country, where the temperature is high, the rainfall low, and evaporation is very great; but where water only is needed to render the desert fertile. But whether or not there is any doubt as to the effect of forests to produce rainfall, there must be less, Mr. Tripp thinks, as to their beneficial effects, in most cases, in regulating the flow off the ground of the rain after it has fallen. He said "most cases," because it is well known that in certain cases the water of small streams has been completely absorbed by planting near them fast growing trees. In most countries there is a sufficient rainfall for practical purposes, if the water could only be stored. In such cases as that of South Africa, however, the great misfortune is, that after rain a torrent may flow off the ground for a short time, while the ground soon returns to its parched condition, and the watercourses are left dry. It must be allowed, he thinks, that the hills are the great rain producers; but while we are perforce obliged to take the hills as we find them, we can, by clothing their sides with forests, convert them into a series of sponges or storage reservoirs absorbing the rain, and allowing it gradually to flow off, and from such districts perennial streams flow, instead of the intermittent torrents, dry for several months in the year, which we often meet with. He thought the Society was indebted to the author and the translator of this paper for much interesting and valuable matter put into a convenient shape. Forestry has attracted, until recently, comparatively little attention in England, this result being in his opinion due to the moist and equable character of the climate. But the subject is of extreme importance, when considered with relation to South Africa or other dry and comparatively desert portions of the globe. And this is quite irrespective of the value of the timber as a marketable commodity, which is very great, although in the case of new forests time is an important though vexatious element in the consideration of all parts of the subject.

Mr. LAUGHTON asked whether any observations had ever been made which distinctly prove the very common statement that forests exert a direct influence on rainfall. The only observations on this point to which Dr. Woeikof referred could not be accepted as either satisfactory or conclusive. The stations were eleven miles apart, and it was impossible to say that the difference in the amount of rainfall registered at these two places was not due to some local causes, rather than to the presence of a forest at the one place and its absence at the other. Of the climatic influence of forests he thought there was no doubt, and he fully agreed with Mr. Tripp's remark as to the enormous importance of woodland in regulating the water supply of the district.

Mr. SYMONS said that, like Mr. Laughton, he had been unable to find any reliable statistical evidence in support of the general belief as to the influence of forests on rainfall. There was an exceedingly readable and interesting book written by the Hon. G. P. Marsh[1] on this subject, but no statistics of any importance were given. Dr. Ebermayer had also given a considerable amount of statistics in his book, but the observations covered a very short period, and the situation of the stations was, in his opinion, not unexceptionable. The strongest case he knew of in support of the statement that the growth of forests increased the rainfall, was that of the island of Ascension. The authorities there applied to Kew for some plants, as they wished the place to present a more attractive appearance. The plants were sent and planted, and the growth has gradually increased with the result, that the rainfall has been appreciably augmented. In the case of the Suez Canal, too, the old records show a small amount of rainfall for this district before the Canal was made; but since the Canal has been cut, and especially near Ismailia, which was well planted with trees, the rainfall has been materially increased. Definite information in the form of reliable observations is very much wanted.

Capt. TOYNBEE suggested that it was possible that the trees in a forest checked the speed of the wind, and so the air becoming calmer had probably an increased tendency to rise, which would cause rain to fall more freely.

Mr. GAMBLE remarked that he had prepared thirteen rainfall maps for South Africa, one for each month, and one for the year, for exhibition in the Indian and Colonial Exhibition of 1886.

Mr. BALDWIN LATHAM said that the Paper, although interesting, did not carry

[1] *The Earth as modified by Human Action.* A new edition of Man and Nature, by George P. Marsh. London 1874.

the subject any further than Mr. Marsh's book. For some time he (Mr. Latham) had been making observations upon the temperature of trees, the temperature being ascertained at different times of the day by means of a thermometer inserted in a hole bored in the trunks of the trees, and so far he had obtained some interesting results. It was well known that cold in summer and warmth in winter had a tendency to increase rainfall. The influence of trees was certainly to lower the temperature of the air in the summer, and to increase it in winter; and so, although trees were not producers of rain, they certainly had a material influence in increasing rain when the conditions for its fall were favourable. He was also of opinion that trees influenced rainfall by reason of adding to the elevation of the ground, as any increase of elevation at ordinary altitudes had a material influence upon the quantity of rain falling.

Mr. LECKY remarked that forests allowed facilities for the transmission of electricity, and possibly clouds were attracted to the forests by this means.

THE PRESIDENT (Mr. SCOTT) said that Dr. Ebermayer's book only contained observations for a limited period. He thought that the idea of the influence of forests upon rainfall was to a great extent based upon some statements made by Dove respecting the drying up of wells and springs near squatters' settlements. These were usually in forests which were gradually cleared. So far as he was aware no precise numerical values existed by which the truth of the belief could be tested.

REPORT ON THE PHENOLOGICAL OBSERVATIONS FOR 1885. By the REV. THOMAS ARTHUR PRESTON, M.A., F.R.Met.Soc.

[Read December 16th, 1885.]

THERE has been rather more difficulty than usual in collating the Returns sent in during the past year, as some observers have not been sufficiently definite in their dates; consequently, the number which have been omitted (there being no confirmatory specimens) has been rather larger than usual. Still, those which have been retained form a very good series from which general results may be obtained.

The following is the list of observers:—

Addington	Buckinghamshire	J. Mathison.
Babbacombe	Devon	E. E. Glyde.
Bilbrough, York	Yorkshire	J. P. Metcalfe.
Bocking	Essex	H. S. Tabor.
Buildwas	Shropshire	Rev. H. L. Graham.
Cardington	Bedfordshire	J. McLaren.
Carlisle	Cumberland	W. R. Thurnam.
Croxley	Herts.	F. G. Lloyd.
Croydon	Surrey	W. F. Miller.
Detling	Kent	R. Cooke.
Exeter	Devon	Rev. W. M. H. Milner.
Geldeston	Norfolk	Miss S. S. Dowson.
Guernsey	Channel Islands	Miss M. Dawber.
Hampson, Lancaster	Lancashire	The Misses Johnson.
Harpenden	Herts.	J. J. Willis.
Henley-on-Thames	Oxfordshire	C. U. Tripp, M.A.

Hertford	Herts.	R. T. Andrews.
Hodsock	Nottinghamshire	Miss A. Mellish.
Killarney	Co. Kerry	The Ven. Archdeacon Wynne, M.A.
Macclesfield	Cheshire	J. Dale.
Maresfield	Sussex	Mrs. Green.
Marlborough	Wilts.	Rev. T. A. Preston, M.A.
Northampton	Northamptonshire	H. N. Dixon.
Northwoods, Bristol	Gloucestershire	Miss Hester Coles, and Miss E. Francklyn.
Oxford	Oxfordshire	F. A. Bellamy.
St. Michael's-on-Wyre	Lancashire	Miss S. Hornby.
Salisbury	Wilts.	W. Hussey.
Sawbridgeworth	Herts.	Miss Simpson.
Strathfield Turgiss	Hants.	Rev. C. H. Griffith.
Tacolneston	Norfolk	Miss E. Barrow.
Tidenham	Gloucestershire	Miss K. Evans.
Tiverton	Devon	Miss M. E. Gill.
Trowbridge	Wilts.	Mrs. Gregory.
Tunbridge Wells	Kent	G. S. Saunders.
Usk	Monmouthshire	C. Mostyn.
Ware	Herts.	Lieut. R. B. Croft.
Watford	Herts.	J. Hopkinson.
Wellington College	Berkshire	S. A. Saunder.
Wells	Somerset	The Misses Livett.
Weston-super-Mare	Somerset	Mrs. Gregory.
Westward Ho	Devon	H. A. Evans.
Wickham	Essex	H. N. Dixon.
Wicklow	Co. Wicklow	The Misses Wynne.
Wincanton	Somerset	Miss A. G. Shaw, and Miss H. K. Hughes D'Aeth.

The year has been a singularly dry one, and hence has acted in such a manner on vegetation, that, although the winter was mild, plants were very late in flowering, and lasted but a very short time. The bloom was often profuse, and as bees and other insects could visit them, the crop of fruit was unusually great; the apples, for instance, being often spoilt in quality from the enormous number on the trees; whilst in the case of wild fruits, as hips and haws, the brilliant colour of the bushes when in fruit was quite as beautiful as it was when in bloom.

But at the same time, the drought acted very prejudicially, especially to root crops and bush fruit, as well as strawberries. In the case of the root crops, the seed had great difficulty in germinating, and the weak plants were at once overpowered by insect pests, so that the crops of turnips were generally complete failures. In the case of bush fruits, the insect pests also did much damage, and in that of strawberries, the drought prevented the fruit from swelling.

The corn did not suffer to any great extent; the dry season allowed the

land to be well prepared, and although the straw was often short, the yield was not unsatisfactory. Considering the variable seasons experienced in England, and the difficulty, therefore, in getting any corn to ripen in some years, it seems desirable to consider the yield of straw, rather than of corn, in estimating the value of a crop. Straw is required for the cattle, and is therefore an absolute necessity for the farmer; but in all returns yet furnished grain alone seems to have been considered, thus decidedly omitting a very important item in the value of a crop.

As regards the lateness of the flowering of plants—at Marlborough, compared with the average of the previous twenty years, they were four days late in January, six in February, five in March, seven in April, nine in May, seven in June, and ten in July. In fact, vegetation has been backward the whole year. Table I. (p. 42), giving the average dates for the different districts of England, fully bears out the above results obtained for Marlborough.

Botany.

October 1884 was a cold and dry month, though at Tiverton it was "extremely mild;" the second week was very cold, small quantities of snow or hail falling in many places on the 10th, whilst the third week was remarkably fine and warm.

The autumn tints were singularly beautiful, more so even than last year. Limes and Horse-Chestnuts were nearly defoliated in exposed situations by the middle of the month, but in sheltered spots they were still beautiful on the 31st. At this time the Beech was in its richest beauty at Salisbury, many Elms were yellow, whilst some were scarcely touched, so that the country presented a magnificent sight. The Jerusalem Artichoke, which does not often flower in England, was in full bloom at Wickham; it also flowered in many places in Wiltshire, but the flowers were small. The Ivy was out in many places in September, but not till October 2nd at Trowbridge, and the 17th at Tiverton. The male catkins of the Hazel were appearing in great abundance generally, the Dogwood flowered for the second time at Trowbridge on the 18th, and the Laurustinus on the 20th in Guernsey, where also the Violet began to flower.

Wild flowers were plentiful at the end of the month; at Northampton 150 species were found, far more than usual. Ripe Strawberries were picked during the third week at Northampton and elsewhere, and the Pyrus Japonica ripened its fruit in Wiltshire; the Privet berries were ripe on the 11th at Salisbury, and those of the Spindle on the 17th at Trowbridge.

The frosts, of which there were a few, did no great damage. The very tender plants, as Dahlias, were nipped and the foliage destroyed, but flowers could be gathered from them for some time afterwards.

Swallows departed generally between the 14th and 18th.

The long-continued drought was unfavourable for sowing, and the wells were getting dry.

November was a remarkably dry and dull month, with very little sun or fog, and colder than usual after the first week. Defoliation progressed slowly and steadily though in Scotland "the trees were bare unusually early," many being leafless in the third week in October. By the middle of the month very many trees were leafless, Oaks and Beeches generally holding on to the end, by which time very few leaves were to be seen. It was difficult, however, to say when defoliation was really completed, for though the trees were generally bare, it would still have been possible to find fresh green leaves on almost every kind of tree till nearly the end of the month. Wild flowers passed away in greater numbers than usual, owing to the drought, and the returns show a great falling off from those of the two previous years. Seventy-four species were found at Northampton, seventy-eight in Guernsey, only twenty-four at Geldeston, and twenty-six at Tiverton, where Violets "were plentiful all the month."

December was dull and damp for the first three weeks, but very dull and cold during the last one; the first half of the month was warm, but stormy on the 18th, 19th and 20th. In spite of the mild weather vegetation was singularly dormant, and wild flowers consequently few in number; the autumn flowers had been killed by the drought and the spring ones retarded; only forty-three were found in Guernsey, forty at Tiverton, and twenty-one at Geldeston. At Cardiff the Dog's Mercury flowered on the 21st; at Trowbridge the Mistletoe was "well berried and plentiful" on the 22nd; and in Guernsey the Fragrant Coltsfoot (*Petasites fragrans*) flowered on the 12th. With these exceptions the returns are meagre.

January 1885 was a very cold, dull and dry month, till just toward the end, when it was wet, and there was an unusual preponderance of Easterly or North-easterly winds. At Harpenden "vegetation was kept healthily back by seasonable weather." At Oxford it was a "very gloomy month," while at Wells it was remarkable for its evenness of temperature. This may account for the very scanty floral notices; vegetation appears to have been universally late. As far as the returns show the North of England was more forward than the South, the dates from Sussex and Herts being singularly late.

At Marlborough, up to the 27th, there were only thirteen day-degrees of temperature above 42°, and no less than 207 below; during the last five days there were twenty-five day-degrees above 42°, and none below. Vegetation was about four days later than the average of the previous twenty years.

February was warm (except during the third week), rather dull, and very wet; at Marlborough there were eighty-eight day-degrees above 42°, and only seventy-five below. At Harpenden the soil was wet and saturated, but more from want of sun and wind than from excess of rain. At Babbacombe alone does vegetation seem to have been forward; elsewhere, judging from the scantiness of the returns, it seems to have come to a standstill. It was certainly remarkable how slowly plants came into flower; a specimen would open, and then a long interval would occur before another flower would appear: this has probably been the cause why the returns vary as they do. Observers may have been puzzled when to put down a plant as properly flowering.

TABLE I.—AVERAGE DATE (DAY OF YEAR) OF FIRST FLOWERING IN EACH GROUP, 1885.

Name of Plant.	South-West of England.	South of Thames.	Central District.	Hertford-shire.	East of England.	North of England.	Ireland.	Guernsey.
Galanthus nivalis	30	29	32	35	32	29	22	27
Corylus Avellana	31	33	37	32	20	34	27	33
RANUNCULUS FICARIA	50	63	45	80	72	70	48	25
Mercurialis perennis	52	52	49	59	66	31	...	...
TUSSILAGO FARFARA......	58	57	49	74	56	69	72	(31)
Petasites vulgaris........	70	69	89	70	87	94	...	...
Viola odorata	51	63	64	45	79	69	26	...
Salix Caprea............	65	68	73	74	73	79	57	...
Narcissus Pseudo-narcissus	64	64	78	73	88	79	57	(44)
Ulmus montana..........	(55)	70	63	61	64	74	52	...
Draba verna	54	59	30	77	87	...	...	(82)
ANEMONE NEMOROSA......	78	78	92	87	97	94	67	...
CALTHA PALUSTRIS	83	87	93	108	96	107	92	...
Nepeta Glechoma	87	91	81	95	100	110	(78)	...
PRUNUS SPINOSA	94	98	102	98	107	109	55	87
PRIMULA VERIS	95	100	97	97	101	113	(88)	...
Cardamine pratensis	103	103	112	115	107	115	115	...
Stellaria Holostea	102	108	114	111	110	122	113	...
SCILLA NUTANS	108	109	118	111	116	126	118	107
Veronica Chamædrys	115	110	118	118	126	136	121	111
Plantago lanceolata	107	115	111	116	119	126	110	102
Sisymbrium Alliaria	110	110	116	110	113	121	123	...
Syringa vulgaris	125	126	125	122	136	136	125	123
Ranunculus acris	131	113	123	110	134	145	138	117
Cratægus Oxyacantha	130	132	140	134	130	145	130	121
Vicia sepium	122	124	136	121	(152)	139	105	120
Æsculus Hippocastaneum	129	137	134	130	120	130	120	117
Symphytum officinale ...	127	121	125	141	152	171	128	174
Cytisus Laburnum	137	141	143	136	143	147	122	118
Pyrus Aucuparia	143	138	146	150	148	145	146	129
Polygala vulgaris........	123	129	132	158	148	139	124	93
Ajuga reptans	119	121	127	129	118	142	120	119
GERANIUM ROBERTIANUM..	117	128	131	123	130	147	130	111
Acer Pseudo-platanus	126	127	119	127	122	117	109	135
Pedicularis sylvatica	123	(132)	129	149	135	140	130	108
Fagus sylvatica..........	133	135	129	121	119	127	...	...
Galium Aparine	141	140	146	143	143	156	(165)	139
Euonymus europæus......	147	149	154	155	156	...	166	...
TRIFOLIUM REPENS	153	152	152	145	160	158	140	119
Potentilla anserina	138	138	140	145	155	158	136	131
Lotus corniculatus	136	140	147	149	156	148	131	120
Chrysanthemum Leucanth.	144	141	144	144	156	155	146	119
Hieracium Pilosella	147	139	145	141	146	159	141	127
Nasturtium officinale	140	158	160	151	154	167	153	142
Lychnis Flos-cuculi......	153	153	150	152	152	166	157	119
Lathyrus pratensis	161	162	164	161	162	177	164	...
Papaver Rhœas	158	159	159	156	162	171	...	149
ACHILLEA MILLEFOLIUM ..	176	170	173	178	180	188	179	170
Iris Pseud-acorus	156	161	163	162	161	170	154	131
Orchis maculata..........	151	159	164	164	...	174	172	142
Rosa canina	162	164	160	158	160	172	168	164
Daucus Carota	181	174	(158)	190	201	209	180	129
Cornus sanguinea........	156	167	161	167	164	154	...	...
Thymus Serpyllum	170	162	...	168	...	...	172	169
MALVA SYLVESTRIS	163	164	166	163	167	158	165	149
Stachys sylvatica	168	168	173	165	169	179	182	157
Epilobium montanum	168	171	168	166	175	177	174	...
Senecio Jacobæa	197	186	186	176	163	189	196	...

TABLE I.—AVERAGE DATE (DAY OF YEAR) OF FIRST FLOWERING IN EACH GROUP, 1885 —*continued.*

Name of Plant.	South-West of England.	South of Thames.	Central District.	Hertfordshire.	East of England.	North of England.	Ireland.	Guernsey.
Spiræa Ulmaria	170	175	175	172	180	183	180	...
CENTAUREA NIGRA........	177	176	179	164	184	191	167	198
Ligustrum vulgare	178	177	174	174	183	178	163	163
Prunella vulgaris........	166	169	166	177	183	180	171	...
Vicia Cracca	174	170	172	175	178	179	174	166
Galium verum	184	181	180	(159)	181	193	179	160
Carduus arvensis	183	183	184	180	183	193	...	...
Hypericum tetrapterum ..	199	184	(200)	187	193	...	208	207
Hypericum pulchrum	180	189	...	175	(205)	...	198	174
Epilobium hirsutum	197	195	194	190	196	205	201	185
Scabiosa succisa	205	190	...	...	...	...	...	...
Carduus lanceolatus......	189	187	197	173	198	199	188	176
CAMPANULA ROTUNDIFOLIA	(204)	182	195	190	194	195	...	...
CONVOLVULUS SEPIUM	199	198	193	193	200	196	207	181
Galeopsis Tetrahit	202	186	198	191	...	...	...	...
Angelica sylvestris	210	211	208	213	219	221	...	...
Dipsacus sylvestris	205	203	210	213	...	222	...	208
Artemisia vulgaris	214	209	210	214	196	...	206	221
Sonchus arvensis	199	196	199	189	184	(213)	...	197
Mentha aquatica	218	208	214	213	...	223	234	217
HEDERA HELIX..........	263	260	...	257	253	273	277	266

(Some unfortunately have only put down when the different species were "fairly in flower," and others only "in bloom," thus rendering their returns far less useful than they might have been.)

At Marlborough vegetation was about six days late. The Yew was early, but this may be accounted for by the fact that its flowers have been so frequently killed in former years, just as they were opening, that many dates were missed.

March was very cold and dry, with East winds, and every thing was checked. At Marlborough there were only sixty-eight day-degrees above 42°, and no less than 173 below; and the reports are therefore very meagre from that as well as all other stations. At Babbacombe and Oxford vegetation was coming on well till about the middle of the month, but then complaints are made. "Flowers more backward than I ever knew" (Trowbridge); "Nearly a month backwarder than last year" (Bocking); such is the style of the reports from all places. At Marlborough vegetation was five days late. Only three plants flowered earlier than usual, and they were all trees or shrubs, the Elm (six days), the Larch (seven), and the Scarlet Currant (two days); but the same remark applies to them as was made last month, viz. that they were very slow in coming into flower, and though a few flowers were open at the times observed, it was some time ere the plants were in moderate bloom; certainly in the case of the Scarlet Currant it was at least a fortnight before a single raceme was fairly open. "Seldom has Spring Corn been got in under such favourable conditions as in the present year" (Harpenden).

At Harpenden the fine sunny days were robbed of their stimulating effect

TABLE II.—INSECTS AND FROG SPAWN.

Station.	Cock Chafer.	Brimstone Butterfly.	Bloody-nose Beetle.	Glow-worm.	Honey Bee.	Wasp.	Large White.	Small White.	Orange-tip.	Meadow Brown.	St. Mark's Fly.	Frog Spawn.	Tadpoles.
Babbacombe	...	...	...	...	...	...	...	131	...	176	...	...	...
Westward Ho	148	...	...	124	...	...	132	102	144	177	...	...	...
Buckhorn Weston	102	...	71	216	...	109	133	50	126	...	...	45	...
Wincanton	...	...	...	...	26	...	...	...	...	...	...	45	...
Tidenham	...	...	...	170	...	112	...	...	...	...	...	...	...
Usk	148	...	...	138	...	...	120	107	111	...	128	...	...
Salisbury	...	...	...	...	90	...	109	109	148	...	...	43	...
Trowbridge	...	...	68	...	74	...	107	108	...	...	...	...	74
Marlborough	...	...	...	...	...	...	111	108	150	170	...	58	...
Croydon	...	...	93	...	...	...	...	92	...	...	...	60	...
Maresfield	138	...	...	122	...	...	...	...	...	...	...	...	...
Henley	150	87	59	...	66	55	...	...	149	...	...	67	...
Tunbridge Wells	...	...	...	...	59	109	117	117	...	...	...	...	...
Wellington College	...	...	...	...	...	...	...	124	...	...	...	56	...
Detling	...	110	...	...	...	110	...	109	147	159	132	...	...
Strathfield Turgiss	121	...	94	171	38	109	149	109	147	152	131	76	...
Oxford	143	...	106	...	...	93	109	109	132	172	...	75	...
Addington	162	...	...	...	38	38	162	117	...	162	...	75	...
Cardington	...	...	...	...	41	110	109	...	107	111	...	89	...
Northampton	...	...	94	...	55	105	117	107	149	...	...	73	...
Ware	...	...	...	...	41	...	...	111	122	...	...	66	...
Hertford	...	...	...	...	...	...	107	90	111	166	...	73	...
Harpenden	152	...	81	184	43	43, 117	89	110	143	158	164	87	...
Watford	...	...	...	...	36	110	88	109	...	161	...	59	...
Rickmansworth	...	...	...	...	...	115	109	109	...	...	...	...	...
Tacolneston	...	90	...	...	...	...	...	...	117	...	...	...	...
Bilborough	...	...	...	...	...	...	...	...	...	...	...	61	...
Hodsock	146	...	...	...	...	146	...	...	...	...	...	71	...
Hampson	143	...	142	...	...	...	...	...	...	...	...	...	...
Carlisle	...	...	...	...	59	95	115	107	...	...	...	...	...
Killarney	140	...	...	...	75	...	...	122	122	...	...	39	...
Wicklow	...	...	...	...	...	133	117	112	131	...	...	...	...
Guernsey	...	...	...	...	...	123	106	109	...	109	131	38	...

on vegetation by reason of the low night temperature. Most wild flowers were several days later in blooming than last year. The Swallow was eleven days late and the large White Butterfly fifteen days.

The cold ungenial weather lasted through the first half of April; but about the 17th a wonderful change took place, apparently all over England, and the country, which up to this time looked very wintry, was changed in appearance in even two days. At Marlborough, for the first sixteen days there were twenty-nine day-degrees above 42°, and eighty-seven below, whereas during the last fourteen days there were 150 above 42° and only six below. As instances of the backward vegetation up to the 17th, it may be stated that at Detling "some growers consider fruit blossom to be from two to three weeks later than last year"; and at Northampton *Ranunculus Ficaria* began to flower in January, but not a dozen blossoms were seen in one district, which was covered with them on April 22nd. This last instance gives as good an idea

as possible of the very slow progress of vegetation up to the middle of April, and is certainly not a solitary instance. By the end of the month the Horse-Chestnut was green generally, and at Tacolneston and a few other places was just in flower; the hedges were green, and the Sycamore, Elm, Beech and Apple in leaf in many places. At Harpenden "rarely have the stone-fruited trees presented a more beautiful appearance than this year, many being literally breaking down with blossom."

With the exception of the last few days, May was a very dull cold month, almost the coldest on record; snow fell at intervals during the first ten days, and the third week was very wet; the reports therefore are almost universally in the same strain; "Season backward," "a cold backward month," "no progress," "vegetation very slow," are some of the remarks about the month. Towards the end the reports are much more favourable, and the bloom is generally reported as "profuse"; the flowering trees and shrubs were magnificent as long as they lasted in flower, but the bloom very soon passed away, leaving a large amount of seed. At Oxford "flowers were not brilliant or plentiful," whilst at Tiverton the report is "most productive," and at Croydon "flowers were in greater profusion than ever." The Hawthorn was magnificent where in bloom, but in many places it was still only coming out, and at Marlborough the first flower was not found till the 28th. The bloom of the orchard and other fruit trees and shrubs is generally described as "profuse," and by the end of the month trees were mostly in full leaf.

At Harpenden "vegetation was kept so much in check that at the beginning of June it had seldom been observed so backward."

Insect life was "conspicuous by its absence" till the warm weather set in, but it then became most abundant, and "fly" began to appear in greater numbers than was desirable.

The early part of June was warm, but a change came about the second week of June, and the weather became rather cooler than the average; the month might be described as "fine," but it may with equal justice be also said to have been changeable; the days were sunny, and a drought began early in the month, which lasted for many weeks in the South of England, and caused much inconvenience. Root crops failed generally; in the few instances where the plants were able to sprout they were soon ruined by the "fly," or were dried up by the hot sun; but in other respects the dry weather was very advantageous for agriculture. The grass soon began to ripen, but a few showers in the middle of the month made a great change; the plants became very thick below, and the Hay crop was unusually good and heavy, and has seldom been secured in such fine condition. Haymaking began during the first week of June in Guernsey, but generally on the 10th in England, and as late as the 27th at Northampton. The Wheat began to flower on the 9th at Harpenden, on the 18th at Salisbury, but a week later at Marlborough, and between these dates elsewhere; the fruit was well set, and though short in the stalk, promised a plentiful harvest. At Harpenden "the great extremes of temperature were very hurtful to vegetation, and notwithstanding the immense quantity of bloom on the fruit trees, the

TABLE III.—BIRDS.

Station.	Song.									Migration.				
	Brown Owl.	Song Thrush.	Nightingale.	Willow Wren.	Chiff-chaff.	Skylark.	Chaffinch.	Cuckoo.	Turtle Dove.	Flycatcher.	Fieldfare.	Wheatear.	Swallow.	House Martin.
Babbacombe	..	..	..	..	..	..	..	113	..	..	..	..	126	..
Westward Ho	..	..	..	..	87	..	..	..	..	..	..	..	..	..
Wincanton	..	..	..	..	..	..	..	..	..	..	..	..	103	..
Tidenham	..	..	115	..	..	..	..	107	..	..	..	..	107	
Buckhorn Weston	..	26	..	..	..	50	52	102	..	106	110[4]	..	106	105
Usk	119	..	..	96	..	..	..	110	..	139	..	..	106	106
Salisbury	..	35	120	.	..	37	..	110[2]	..	..	..	..	96	114
Trowbridge	..	..	99[1]	By 114	..	71	..	112	101	..	..	..	96	..
Marlborough	..	..	..	..	69	..	..	111	..	146	..	..	100	..
Croydon	..	..	94	94	..	..	..	..	..	..	..	..	..	..
Maresfield	..	..	109	..	..	..	..	108	..	..	..	..	100	125
Henley-on-Thames	..	25	..	..	..	39	..	117	..	..	..	..	106	..
Tunbridge Wells	..	..	117	..	..	..	..	108	..	..	..	..	118	123
Wellington College	..	..	..	..	..	..	..	116	..	..	..	..	..	..
Detling	..	..	108	..	..	..	..	107	..	..	..	..	..	107
Strathfield Turgiss	..	20	111	105	91	43	36	107	147	137	..	103	106	110
Oxford	..	..	115	..	..	100	..	115	..	..	..	..	106	..
Addington	..	..	..	..	..	..	..	111	138	..	..	..	106	..
Cardington	..	All Feb.	116	..	..	All Feb.	..	113	..	..	..	..	107	..
Northampton	..	55	122	..	..	..	..	113	..	..	..	..	104	110
Ware	..	..	112	..	..	..	..	114	..	..	..	..	106	126
Hertford	..	29	119	..	111	32	58	118	..	..	..	..	107	..
Harpenden	..	20	107	..	..	27	..	112	..	..	..	..	90	111
Watford	..	..	110	..	..	35	..	113	..	..	..	..	104	..
Rickmansworth	..	..	111	..	..	..	..	111	..	..	..	..	96	..
Sawbridgeworth	..	..	120	..	..	..	..	116	..	..	..	..	..	..
Wickham	..	.	..	..	..	..	..	113	..	..	..	..	106	..
Tacolneston	..	..	119	..	..	..	..	113[3]	128	..	..	..	107	123
Bilborough	..	28	..	67	66	32	71	114	..	..	224	..	115	113
Hodsock	..	..	..	112	..	..	.	112	..		..	..	108	..
Hampson	..	..	..	.	..	..	..	..	..	..	.	..	..	..
St. Michael's-on-Wyre	..	29	..	108	..	..	..	116	..	141	..	108	108	110
Carlisle	..	34	..	..	..	32	..	.	..	..	..	..	109	..
Buildwas	..	33	..	107	89	..	55	112	121	142	..	..	107	92
Killarney	..	..	..	..	86	..	36	124	..	..	..	107	119	103
Wicklow	..	..	..	..	99	..	..	128	..	..	..	..	..	112
Guernsey	..	..	..	..	..	29	..	114	..	..	..	..	109	114
Average	..	30	112	100	87	43	51	113	127	135	..	106	106	112

[1] ? 119. [2] Till 183. [3] Changed note 146. [4] Flocks.

crop in many places is very scanty indeed." "No serious deficiency is reported in the Wheat crop, but heavy well packed ears are the exception rather than the rule; at the end of June the crop was a week and possibly ten days behind an average season. Barley looking well, and Oats promise an exceedingly large yield on good land."

As regards garden produce, the dry weather acted very injuriously. Strawberries were plentiful for a short time, but the fruit was small and dry, and in some places the plants were completely dried up; large quantities of

TABLE III.—BIRDS (*continued*).

tation.	Migration.				Nesting.										
					Song Thrush.			Willow Wren.	Chaffinch.		Rook.			Partridge.	Corncrake.
	Sand Martin.	Swift.	Goatsucker.	Corncrake.	Nesting.	Eggs.	Young.	Nesting.	Nesting.	Eggs.	Building.	Young.	Swallow.	Eggs.	Eggs.
mbe	..	..	..	144	..	..	..	..	..	..	..	..	..	..	..
d Ho	..	..	150	..	..	..	..	..	..	..	..	..	185	143	..
on	..	..	..	117	..	71	..	..	..	..	63	..	..	..	..
m	..	..	..	144	..	..	..	..	..	..	..	..	..	..	..
n Weston	..	124	..	..	..	71	..	..	84	..	34	..	..	..	..
	106	116	..	119	..	..	102	..	..	131	..	..	..	..	..
y	109	124	..	127	..	..	..	..	..	..	..	..	..	..	..
lge	..	..	..	..	..	101[6]	..	..	..	..	..	..	..	..	..
ough	110	132	..	131	..	83	117	..	87	125	74	103	..	130	..
	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
ld	..	126	..	..	..	..	..	..	..	..	32	..	..	..	..
n-Thames	..	..	..	..	73	..	..	..	..	..	32	..	..	..	169
ge Wells	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
on College	..	..	116	..	..	..	..	..	..	..	..	..	..	..	..
	..	131[5]	143	..	..	..	..	..	..	..	..	..	165[8]	..	..
ld Turgiss	..	121	135	146	..	..	..	..	..	..	..	101	..	113	..
	122	120	..	129	..	..	..	..	..	..	..	..	..	110	..
n	..	132	..	144	..	67	99	..	..	..	48	..	..	117	..
on	..	..	..	123	..	..	..	..	..	..	..	..	..	..	..
pton	118	120	..	..	..	108	..	..	..	..	70	..	..	..	..
	..	126	..	116	..	..	..	..	..	..	50	..	..	..	..
	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
en	..	129	..	117	..	..	..	..	..	..	58	..	..	..	..
	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
sworth	..	120	..	..	..	..	..	..	..	..	..	..	..	..	..
geworth	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
n	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
ton	..	143	..	..	..	..	..	..	..	..	..	..	..	..	..
gh	114	121	..	122	..	..	..	..	..	..	..	..	..	..	..
	117	128	..	117	..	..	..	..	..	..	..	..	..	..	..
n	..	..	..	127	..	..	..	..	..	..	..	..	..	..	..
ael's-on-Wyre	112	..	..	114	..	..	118[7]	..	..	..	..	..	..	114	..
	..	114	..	119	..	94	..	124	..	110	..	..	..	..	..
	107	124	..	114	..	..	..	..	..	..	..	..	..	..	..
y	..	..	..	117	..	..	..	..	..	..	66	..	..	..	..
	..	124	..	117	..	..	..	..	..	..	..	..	..	..	..
y	..	124	..	(60)	..	..	..	..	..	..	..	..	..	..	..
rage	113	125	136	122	..	85	109	..	..	122	53	..	..	121	..

[5] 2nd time. [6] Sitting. [7] Fly. [8] Building.

uit dropped from the trees and bushes, and Gooseberries alone seem to ve been an average crop; blight increased enormously, and the "Green y" or *Aphis*, flew about in swarms, covering every thing and making a walk pleasant; vegetables, therefore, if not destroyed by the drought, were spoilt the insects. Peas and beans were ruined, and the few that were gathered re hard and dry, unless the plants had been kept well watered; but before e end of July water was becoming very scarce.

"Honey Dew" was exceedingly plentiful, especially on the Limes; honey,

which had been very abundant earlier in the year, became scarce: "the cold of May and the variable temperature of June interrupted the working of the bees and the consequent storage of honey."

August was a hot and dry month, the flowers lasted but a short time; insect pests were still very abundant, and the grass was generally quite burnt up; the leaves also began to fall, especially from the Limes. At Bristol there was "a marked scarcity of all Butterflies and Wasps," and at Detling "Wasps, which were common in the early part of the summer, became very scarce." However, the dry weather was very favourable for harvest work, and large quantities of corn were secured before the wet weather came in, just towards the end of the month.

September was very unsettled, and harvest was much interrupted. At Tiverton the hedges were almost bare by the 8th. Two frosty nights at the end of the month appeared to have done but little damage in some places, but in the South of England they cut down tender plants. The crop of nuts was unprecedented, and all sorts of common berries were very plentiful. The autumn tints were coming on, but did not promise to be as fine as usual. In Guernsey, a gale on the 10th damaged the trees and divested them of much of their foliage, Sycamore, Chestnut, Lime, and Hawthorn, being almost bare by the end of the month.

Entomology.

The Entomological notices are still unsatisfactory, and do not furnish any reliable results. The difference between the earliest and latest dates varies from twenty-three days in the case of the Brimstone Butterfly, to as much as 108 days in that of the Wasp; but in that of many others the dates vary from ten to twelve weeks, which is clearly unsatisfactory.

A general absence of Butterflies has been noticed in some places. Certainly in the South of England the White Butterflies were most abundant at one time, but the autumn Butterflies were not so plentiful as usual.

Ornithology.

Song.—Compared with the average dates of the previous ten years, the Song-thrush, Skylark, and Chaffinch, were each eight days later than usual; the Cuckoo arrived at its average date, the Nightingale one day early, the Chiff-chaff two days early, and the Willow-wren and Turtle-dove six days.

The Nightingale was first heard at Croydon on April 4th, but not till the 29th at Hertford, and the 30th at Salisbury and Sawbridgeworth. The Cuckoo was first heard at Wincanton (Buckhorn Weston) on April 12th, but not till the 28th at Hertford, and May 8th at Wicklow. Its average date for the twenty-one years at Marlborough is April 23rd.

Migration.—The Wheatear was six days later than the average, but in all other cases the arrival appears to have been earlier than usual; the Swallow two days, the Flycatcher five days, and the Swift seven days. The House-martin was six days earlier than the average of the five previous years, and the Corncrake two days.

The Swallow appeared first at Harpenden on March 31st, and at Salisbury, Tunbridge, and Rickmansworth on April 6th. It was not seen at Tunbridge Wells till April 28th, or in Ireland till the 29th.

The Swift was noticed first at Carlisle on April 24th, but not at Tacolneston till May 23rd. It was generally seen about the first week in May.

NESTING.—The only two birds noticed are the Song-thrush and the Rook. Both began to build before their average date. The Rook began to build on February 21st, 1884, and on February 22nd, 1885; the date for 1883 was also February 22nd, but the dates of all previous years are from two to sixteen days later.

I must again return my thanks to Mr. W. F. Miller for the great trouble he has taken in tabulating the notices as supplied by observers. I could not have done what I have had it not been for his assistance.

ETUDES SUR LES CRÉPUSCULES ROSÉS. Par Prof. le A. RICCÒ, Premier Astronome à l'Observatoire de Palerme.

[Read December 16th, 1885.]

VOYANT qu'il me faudra encore un certain temps avant que je puisse publier entièrement mes études sur les Crépuscules Rosés, je me suis décidé (trop tard peût-être) à envoyer à cette honorable Société ces tableaux qui sont le résumé de mes observations.

Tableau I. (Observations faites à Palerme.) La partie (A) contient les observations des crépuscules rosés du soir; elle donne:—L'intensité de la lumière rosée, 1ère et 2de, en supposant 10 l'intensité du maximum à Palerme (8 décembre 1883); ces nombres ont été déterminés *à posteriori* d'après la description des phénomènes; *n* indique que les nuages ont empêché l'estimation de l'intensité.

La hauteur où disparaissait le soleil a été déterminée en trouvant avec le chercheur du réfracteur (calé à la déclinaison du soleil) le point du coucher sur le contour de l'horizon visible ou sensible, et en mesurant la hauteur avec le théodolite. On a fait graphiquement la correction pour le rayon du soleil et la réfraction.

Les hauteurs où disparaîssaient les lumières rosées 1ère et 2de ont été déterminées d'après le calcul de la distance zénithale du soleil au moment de ces disparitions et avec une construction graphique sur un dessin de la silhouette des montagnes relevé avec la Camera Lucida d'Amici. On a supposé toujours que le sommet des lumières rosées était dans le vertical du soleil.

Le commencement ou l'apparition de l'arc brun sur l'horizon ouest, dérivant de l'anneau de Bishop, est le moment où cet anneau ou arc est dessiné complètement sur le ciel.

Le commencement de la première lumière rosée est le moment où elle commence à apparaître en un espêce limité au sommet de l'arc brun.

TABLE I.

Jour.	Intensité de la lumière rosée.		A l'horizon visible.						
	1a.	2a.	Hauteur du lieu où disparaissait le premier soleil.	Hauteur du lieu où disparaissait la première lumière rosée.	Hauteur du lieu où disparaissait la seconde lumière rosée.	Commencement de l'arc brun (Anneau de Bishop).	Commencement de la première lumière rosée.	Fin de la première lumière rosée.	Fin de la seconde lumière rosée.
A. (Soir).			°	°	°	h. m.	h. m.	h. m.	h. m.
1883. Dec. 3..	10	10	3·8	3·4	4·6	..	4 35?	5 28?	6 29
14..	8	8	3·4	..	4·4	..	..	..	5 58
15..	8	8	3·3	..	..	..	..	..	..
26..	8	8	3·3	..	4·4	..	..	..	6 4
27..	8	8	3·3	4·2	4·4	..	..	5 24	6 14
28..	7	7	3·3	4·2	..	..	..	5 20	..
29..	6	0	3·4	4·3	..	..	..	5 30	..
30..	9	7	3·4	4·3	..	4 30	5 3	5 25	..
31..	8	7	3·4	..	..	4 37	5 14?	..	..
1884. Jan. 3..	8	8	3·5	..	..	4 41	5 10	..	..
4..	8	8	3·6	..	4·1	..	5 15	..	6 15
6..	9	7	3·7	5·2	4·1	4 30	5 4	5 31	6 22
29..	8	8	4·5	5·3	5·0	4 50	5 28	5 52	6 44
30..	8	9	4·7	5·3	5·0	4 50	..	..	6 43
Fév. 1..	9	7	4·8	5·3	..	..	5 30	5 58	..
2..	7	7	5·0	5·3	4·6	..	..	6 0	6 45
5..	4	0	5·3	4·9	..	..	5 40	5 50	..
6..	4	1	5·4	4·9	..	..	5 40	5 57	..
8..	5	0?	5·2	..	..	5 15	..	6 5?	..
10..	3	0	5·3	..	..	..	5 45	..	..
14..	6	0	5·3	4·7	..	5 10	5 50	6 1?	..
22..	7	2	5·0	..	..	5 19	5 54	..	..
23..	6	1	5·1	4·8	..	..	5 58	6 20	..
24..	3	2	4·8	..	..	..	5 58?	..	..
Mars 9..	3	0	4·7	4·9	..	5 30	6 13?	6 36	..
10..	6	2?	4·7	5·0	..	..	..	6 43	..
11..	4	1	4·4	5·2	..	5 38	6 13	6 35	..
15..	5?	6?	4·8	..	..	5 43	..	..	..
18..	*n*	*n*	4·9	..	..	5 45	..	..	..
25..	5?	3?	5·5	..	..	..	..	..	..
26..	7	7	5·9	5·6	3·6	..	..	6 45	6 52?
30..	6	1	5·9	5·6	3·6	5 50	..	6 51	7 0?
31..	*n*	*n*	6·1	..	..	5 44	..	..	..
Avril 1..	4	1?	6·2	3·8	..	..	..	6 54	..
4..	6	1	7·0	3·3	..	..	6 30	6 57	..
5..	0	0	7·2	..	..	..	..	..	..
7..	1	0	6·9	..	..	..	6 22	..	..
11..	7	3	6·1	3·3	3·8	..	6 20?	7 5	7 35
12..	1	0	6·3	..	..	..	6 9	..	..
13..	7	1	5·8	3·3	..	..	..	7 2	..
16..	3	1	3·8	3·3	..	..	6 33	7 13	..
18..	2?	2?	3·9	3·5	..	..	6 35?	7 11?	..
21..	2	0	3·8	3·5	..	..	..	7 14	..
23..	4	2	3·0	4·0	..	..	..	7 20	7 27?
25..	2	0	3·6	3·8	..	..	6 37	7 17?	..
28..	5	1	3·8	3·4	3·3	..	6 37	7 21	7 27
30..	4	0	4·0	..	..	..	6 25	..	..
B. Lum. verte (Soir) du crépuscule ordinaire.									
1882. Fév. 26..	..	..	4·6	..	5·9	..	..	..	7 0
1884. Mars 30..	..	..	5·9	..	3·3	..	..	..	7 34
C. Matin.									
1883. Dec. 4..	9	9	1·3	..	..	7 6	7 0	..	..
1884. Jan. 31..	6	8	1·1	..	..	7 14	6 55	..	..
Fév. 23..	8	8?	0·9	..	..	6 53	6 30	..	..
„ 29..	7	7	0·4	..	..	..	6 15	..	..
Avril 24..	7	0	−0·3	3·0	..	5 27?	5 4	4 28	..

Jour.	[illegible]											1885.							
	Palerme.		Castelvetro.									Palerme.							
	Mai.		Juin.	Juli.	Aug.	Sept.	Octobre.		Nov.	Decembre.		Janvier.		Fév.	Mars.	Mai.	Juin.	Juli.	Aug.
	1a.	2a.	1a.	1a.	1a.	1a.	1a.	2a.	1a	1a.	2a.	1a.	2a.	1a.	1a.	1a.	1a.	1a.	1a.
1	n	..	..	3	1	n	4f	..	n	n	..	..	Aucun crépuscule rosé de grande intensité, d. 4.	..	4	..	5	..	..
2	4	2	..	4f	5	n	0	..	n	n	..	..		..	..	..	5	..	..
3	n	..	..	2	3	n	7	..	1	4	..	..		..	..	3	5	7	..
4	..	..	..	..	2	n	n	..	2	0	..	..		..	7?	..	..	6	..
5	n	..	..	..	1	n	n	..	3	6?	..	..		..	..	..	3	7?	6
6	n	..	..	..	0	4	n	..	2	n	..	..		..	..	3	..	..	..
7	n	..	..	6	n	n	n	..	3	7?	..	..		..	..	0	..	..	6
8	n	..	..	0	3f	5f	n	..	5	8	5	..		..	..	..	..	..	..
9	n	..	..	..	3	n	0	..	0	7	2	..		..	..	..	..	..	..
10	5f	2	..	..	2	n	4	..	n	6	..	..		..	..	..	..	..	..
11	n	..	..	6	1	n	3	..	n	n	..	..		..	..	..	..	1	5
12	5	3	..	5	0	n	2	..	0	6	..	..		4	..	..	2	3	4
13	6f	..	..	..	0	n	1	..	..	7	2	..		4	..	..	..	3	..
14	5f	1	..	5f	2	n	5	..	6	7	7	..		4	..	..	..	3	..
15	5	1	..	0	6	0	4	..	..	7	5	..		..	..	..	..	3	6
16	n	..	..	0	3	1	n	..	..	n	..	..		..	..	..	..	3	..
17	n	..	..	0	3f	5f	4	..	n	n	..	..		..	..	..	..	3	..
18	3	..	..	0	4	7	6	..	6?	n	..	..		..	..	..	..	3	..
19	5f	..	..	0?	2	6f	n	..	n	1	..	..		..	..	..	4	..	4
20	3	..	6	0?	n	6	n	..	1	n	..	..		..	..	..	..	..	..
21	4f	..	6	3	2	0	1	..	0	n	..	..		..	..	..	1	..	..
22	n	..	6	6	4f	2	4	..	n	n	..	..		..	..	5	2	..	..
23	3	..	5	..	4	n	n	..	n	n	..	..		..	..	..	7	..	..
24	0	..	..	..	0	n	4	..	4	6?	..	..		..	..	..	4	..	..
25	5	..	4	1	0	n	5	..	0	n	..	..		..	..	..	..	6	..
26	4	..	5	0	0	4	6	3	0	..	..	..		..	..	..	..	0	..
27	3	..	6	..	3	5	6	..	3	..	..	..		..	..	..	5f	6	..
28	n	..	n	..	3	5	5	..	2	..	..	..		4	..	6	4	6	..
29	n	..	5f	4f	n	6	n	..	0	..	..	..		..	..	6	..	6	..
30	6	..	4	4	4	1	n	..	1	..	..	5		..	..	..	..	6	..
31	..	..	..	2	2	..	5	..	..	..	..	..		..	..	..	..	6	3

t 2a = 1a *et* 2a de lumière rosée.
= nuages au lieu du crépuscule.
= lumière rosée divisées en faisceaux divergents.
1885 on a fait note seulement des crépuscules rosés de quelque intensité: dans cette
e la seconde lumière rosée manqua toujours, ou ne fut pas vue parcequ'elle était très
e.

TABLE III.—ANNEAU DE BISHOP.

Jour.	1883.		1884.																								1885.															
	Dec.		Jan.		Fev.		Mars.		Avril.		Mai.		Juin.		Juli.		Aug.		Sept.		Oct.		Nov.		Dec.		Jan.		Fev.		Mars.		Avril.		Mai.		Juin.		Juli.		Aug.	
	1a.	2a.	1a.	2a.	1a.	2a.	1a.	2a.	1a.	2a.	1a.	2a.	1a.	2a.	1a.	2a.	1a.	2a.	1a.	2a.	1a.	2a.	1a.	2a.	1a.	2a.	1a.	2a.	1a.	2a.	1a.	2a.	1a.	2a.	1a.	2a.	1a.	2a.	1a.	2a.	1a.	2a.
1	..	..	..	..	7	..	7	..	..	*A*	..	*a*	2	..	..	..	..	..	..	..	7	..	..	..	..	..	..	..	..	..	..	*A*	4	*a*	..	*a*	..	..	..	..	..	..
2	..	..	..	..	9	..	..	..	9	*A*	..	*A*	..	..	..	..	..	..	..	..	..	..	7	..	..	..	..	..	..	..	..	..	4	*a*	1	*a*	0	0	..	..	..	..
3	..	*a*	7	..	..	..	..	*a*	..	*A*	..	*A*	..	..	..	..	..	..	..	..	..	..	..	..	4	..	..	..	..	..	..	..	4	*a*	1	0	1	*a*	..	..	..	..
4	4*m*	*a*	..	..	..	..	..	..	10	..	5	..	..	..	..	..	8	..	..	*a*	..	..	9	..	..	..	..	..	..	..	..	..	4	*a*	..	..	..	..	..	..	..	..
5	..	*a*	..	*a*	8	..	..	..	9	*A*	..	..	..	..	..	..	..	..	..	..	..	..	8	..	..	..	..	..	..	..	..	..	4	*a*	..	*A*	..	*a*	..	*A*	..	..
6	..	..	9	..	9	..	..	..	..	*A*	..	..	..	..	..	..	..	..	..	*A*	..	..	..	..	..	..	..	..	..	..	..	..	..	*a*	5	0	5*m*	*a*	..	..	..	..
7	..	..	..	..	..	..	..	..	10	..	..	..	..	*A*	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	*a*	..	..	..	*a*	3	..	..	..	..	..	..	..
8	..	..	..	..	10	..	..	..	..	*A*	..	..	..	*a*	..	..	..	0	..	..	..	..	8	..	..	..	..	..	..	*a*	..	..	..	*a*	..	*A*	..	*A*	..	..	..	..
9	..	..	..	..	..	..	8	..	..	*A*	..	..	..	..	..	..	..	..	..	..	8	*A*	..	..	..	..	..	..	..	*a*	..	..	..	*a*	..	..	..	0	..	..	..	..
10	..	..	..	..	..	..	..	..	..	..	8	*A*	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	*a*	..	..	..	0	..	..	..	..
11	..	..	..	..	..	..	8	..	8	*A*	..	*a*	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	*a*	..	..	..	*a*	..	..	..	..
12	..	*a*	..	..	..	..	..	..	9	*A*	7	*A*	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	*a*	1	*A*	3	*A*	..	..	..	..
13	..	..	..	..	..	..	..	..	9	..	5	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	2	*a*	1	*A*	..	..	..	..	..	..
14	..	..	..	..	5	..	..	..	..	*a*	6	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
15	..	..	..	..	..	..	8	..	9	..	..	*a*	..	..	..	..	..	..	6	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
16	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	*A*	7	..	..	..	10	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	*a*
17	..	..	..	..	..	..	..	*a*	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	*A*	..	..	..	..	..	..	..	..
18	..	..	..	..	..	..	9	..	8?	..	4	..	..	..	..	..	..	..	7	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	*A*	..	..	..	..	..	..
19	..	..	..	..	..	..	..	..	..	*a*	4	..	..	*A*	..	*a*	..	..	..	*A*	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	*A*	..	..	..	..	5	..
20	..	..	..	..	..	..	..	..	8	*A*	2	..	..	..	..	*a*	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	2	..	..	..	..	*o*	..	..	..	..
21	..	..	8	*a*	..	..	..	..	..	..	3	..	8	..	1	*A*	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	5	*A*	1	*A*	..	*a*	..	..
22	..	..	..	..	7	..	..	..	8	..	..	..	8	..	..	..	7	..	..	..	..	..	..	..	..	..	..	*A*	..	..	..	..	..	..	..	..	1	*A*	..	..	..	..
23	..	..	7	..	7	..	..	*a*	..	..	..	..	..	..	7	..	..	..	..	..	..	..	..	..	..	..	..	*A*	..	..	..	..	..	..	..	..	..	..	..	..	..	..
24	..	..	..	..	10	*A*	..	..	7*m*	..	..	*a*	..	*a*	5	..	..	..	..	..	..	..	..	..	..	..	..	*A*	..	..	..	..	..	..	..	..	..	..	..	..	..	..
25	..	..	..	..	..	..	..	*a*	9	..	..	..	..	*a*	..	*a*	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
26	..	..	..	..	..	..	..	..	..	*A*	3	..	..	*A*	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	1	*A*	..	*A*	..	..	..	..	..	..
27	6	..	..	..	0	..	..	..	..	..	3	..	..	..	..	..	..	..	7	..	..	..	..	..	..	..	..	..	..	..	..	..	1	*A*	..	*A*	1	*o*	..	..	..	..
28	..	..	..	..	..	..	..	..	8?	*A*	7*m*	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	1	*A*	..	..	..	..
29	..	..	9	..	0*m*	..	..	..	..	..	..	..	..	..	..	*a*	..	..	..	*A*	..	..	..	..	..	..	..	..	..	..	..	..	..	*a*	..	..	..	..	..	..	..	..
30	8	..	8	..	..	..	10	*a*	8	..	..	*A*	..	..	..	*A*	..	..	7	..	..	..	..	..	..	..	..	*A*	..	..	..	..	..	..	..	..	..	..	..	..	..	..
31	8	*a*	5*m*	..	..	..	9	*A*	..	..	..	*A*	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..

m indique observations du matin.
A indique anneau de Bishop entièrement visible au ciel serein.
a ,, ,, en parties, entre les nuages.
0—10 degrés d'intensité de l'anneau ou de la couronne à l'horizon.

La fin des lumières rosées 1ère et 2de est le moment où elles disparaîssent à l'horizon visible.

La partie (B) du Tableau I. contient quelques données relatives à la lumière verte, qui est la couleur des beaux crépuscules ordinaires à Palerme. Ces données sont disposées en ordre correspondant à celui des données précédantes pour les crépuscules rosés.

La partie (C) contient les résultats de quelques observations des crépuscules rosés du matin. Les données y sont enregistrées, non en ordre chronologique, mais en correspondance à celles du soir. Au 24 avril le soleil se lève à la mer, et pourtant le sommet du disque solaire apparait de l'Observatoire avec une dépression de à peu-près $0^{\circ}{\cdot}3$, c'est-à-dire hauteur $= -0^{\circ}{\cdot}3$; mais à cause des brumes ordinaires du bas horizon, la lumière rosée n'est apparue qu'à la hauteur de 3°, c'est-à-dire au dessus du dit brouillard léger.

Tableau II. C'est la continuation de mes observations des crépuscules, mais seulement avec l'indication de l'intensité évaluée pendant l'observation. En mai les observations ont été faites à Palerme ; pour juin elles ont été faites en voyage, en des lieux différents entre Turin et Modène ; de juillet jusqu'à la fin de 1884 j'ai observé à Castelvetro, au pied des Appennines, à peu-près à 15 kilomètres au sud de Modène. (J'ai attendu là la fin des quarantaines pour revenir en Sicile.) Les observations de 1885 ont été faites à l'Observatoire de Palerme.

Tableau III. contient l'intensité de l'arc brun ou anneau de Bishop à l'horizon ouest, estimée *a posteriori* d'après la description : on a indiqué encore avec *a* les jours où l'anneau de Bishop était visible pendant le jour entre les nuages couvrant le soleil, avec la couleur caractéristique rouge de l'anneau ; et avec A on a indiqué les jours où le même anneau était visible autour du soleil tout-à-fait libre de nuages. Quelques observations ont été faites au matin, et elles sont désignées par *m*. Il va sans dire que les lieux d'observation sont les mêmes que pour les observations des crépuscules.

Tableau IV. En comparant les intensités de l'arc brun de Bishop avec les données météorologiques de 6h. du soir, depuis décembre 1883 à avril 1884, j'ai trouvé que l'humidité relative était plus grande aux jours où l'arc était

TABLE IV.

1883—84.	Humidité relative moyenne à 6h. p.m.					
	Des jours avec couronnes fortes.	Du mois.	Des jours non couverts.	*a—b.*	*a—c.*	*b—c.*
	a.	*b.*	*c.*			
Decembre ...	$83^{\circ}{\cdot}0$	$75^{\circ}{\cdot}6$	$78^{\circ}{\cdot}7$	$+7^{\circ}{\cdot}4$	$+4^{\circ}{\cdot}3$	$+3^{\circ}{\cdot}1$
Janvier	88·5	75·3	81·0	+13·2	+7·5	+5·7
Février	83·6	80·3	79·9	+ 3·3	+3·7	—0·4
Mars	77·3	75·9	76·1	+ 1·4	+1·2	+0·2
Avril	65·1	64·4	64·1	+ 0·7	+1·0	—0·3
Moyenne ...	...	...	...	+ 5·2	+3·5	+1·7

plus fort (intensité $\geqq 8$). Le Tableau IV. fait voir cela, et que cela ne dépend pas de ce que l'arc ne se fit pas voir qu'aux jours sereins, qui à Palerme sont un peu plus humides que les autres.

J'ai envoyé à cette Société un premier résumé des résultats de la discussion de mes observations de crépuscules, publié dans les *Rendiconti della R. Accademia dei Lincei*, et j'enverrai bientôt un autre qui donne les résultats des comparaisons des observations de crépuscules rosés avec les conditions metéorologiques. Ces deux résumés pourront compléter en quelque manière les données que maintenant j'ai l'honneur de présenter.

DISCUSSION.

Mr. WHIPPLE remarked that Prof. Riccò had come to the conclusion that the sunsets between December 3rd, 1883, and April 1884, were due to the humidity of the atmosphere; and it was curious that Dr. van Rijckevorsel, formerly living at Pará, with whom he corresponded, had formed much the same opinion, as was shown by his letter which was read to the Meeting.

Mr. DYASON said that he had from November 1883 to February 1884, the time named in Prof. Riccò's Paper, made a series of drawings and observations of coloured skies in the North-west of London, and, contrary to the Professor's conclusions, his notes showed that the sunsets and the afterglows were invariably accompanied by a dry atmosphere.

Mr. STANLEY observed that Krakatoa had been in serious eruption in May 1883, so that the sunsets seen at Pará previous to August might have been due to the May eruption.

Mr. WHIPPLE said he noticed that Prof. Riccò described the sunsets as being green at Palermo; he would like to know if any of the Fellows who had passed through the Mediterranean could explain this.

Mr. SYMONS remarked that a great deal of real hard work had been done by the Royal Society's Krakatoa Committee, with a view to a thorough investigation of the whole phenomena, and it was impossible to accept such an off-hand opinion as that declared by Dr. van Rijckevorsel until evidence in support of it was brought forward.

Mr. STANLEY said that he had himself often seen the greenish tints of the sunsets in the Mediterranean. The air there had generally an intensely blue appearance, and towards sunset the sky assumed a yellowish tint near the horizon, as in this country, and the mixture appeared to him to produce the green observed.

Prof. RICCÒ, who was not present, subsequently sent the following reply to the Discussion:—"I have not concluded that the rosy or red after-glow was due to the humidity of the atmosphere; but that the brown arc (Bishop's ring partly visible at the horizon), when strong, was accompanied by greater humidity. The intensity of the brown arc does not vary according to the intensity of the rosy twilight, since in 1884 I observed on fifteen occasions that when the brown arc was very strong it was followed by slight rosy after-glows, and on four occasions, when the brown arc was very strong, it was not followed with rosy after-glows. From my comparisons of the intensity of the rosy after-glows with the meteorological observations at 6 p.m. I came to the conclusion that those after-glows were accompanied with high pressure and low temperature, but that no direct relation existed with humidity. The green of the ordinary after-glows in Palermo is the intermediary colour between the reddish and yellowish tints of the lower horizon and the blue sky above, precisely as Mr. Stanley remarked, when the sky is clear the green of the twilight is very strong and beautiful.[1] The rosy light is superposed to the green twilight more or less frequently. When the rosy light is not strong the green light is visible down or above the rosy light and after it."

[1] See Piazzi Smith's description of green twilight in Palermo—*Astronomical Observations made at the Royal Observatory, Edinburgh*, Vol. XIV.

The Storm of October 15th, 1885, at Partenkirchen, Bavaria. By Colonel Michael Foster Ward, F.R.Met.Soc., F.R.A.S. (Plate II.)

[Read December 16th, 1885.]

The most destructive storm known since the winter of 1821-22 broke over this valley on Thursday, October 15th, 1885. The previous day had been fine and frosty, the copper coloured halo round the sun being more remarkable than on any previous occasion. The early morning of the 15th was cloudless, the halo, as on the preceding day, being very deep coloured. At 5 a.m. and at 10 a.m. there was a loud rattling in the air overhead, sounding as if a heavy waggon were passing along a road. At 8 a.m. clouds began to form on the Wetterstein Range on the south side of the valley, and the temperature rose rapidly. At 9.30 a.m. the Föhn began to blow from South-south-west, accompanied by snow on the mountains and very dirty rain in the valley, leaving a deposit on the window panes of a reddish ochre colour. The entire northern sky from east to west was cloudless during the whole time, and no rain fell four miles north of this. At 2 p.m. the wind increased in force, varying in direction from South-south-west to South-south-east; and at 5 p.m. it broke in all its fury: the rain ceased, the sky cleared, and the wind increased in force till 7 p.m., and remained at its height till 8 p.m. when it moderated slightly, returning at short intervals in violent gusts till 2·30 a.m. on the 16th, when a sudden dead calm ensued which continued all day. From 9 to 10 p.m. slight rain fell accompanied by brilliant lightning, without any audible thunder, stars shining through openings in the cloud. At 10 p.m. it was again cloudless.

At 9.45 a.m. on the 16th the same rattling in the air was heard, and the deadness of the calm, the oppressiveness of the atmosphere, together with the intensity of the copper halo, and the general lurid appearance of the sky, led every one to dread a return of the gale. Fortunately, however, this was past; the sky cleared to deep blue at 4 p.m., and a lovely sunset followed, in strange contrast with the wreck below.

The amount of rain which fell during the gale was 0·62 in., the water being perfectly muddy and yellowish red.

The barometer had fallen slightly during the night, but was steady at 27·47 ins. from 7 to 9 a.m. At 9 a.m. it fell to 27·42 ins., and oscillated rapidly between that and 27·54 ins. all day till 7 p.m., when it fell suddenly to 27·30 ins., rising immediately afterwards and continuing to do so steadily during the next two days.

Temperature, which had been 37° (the minimum) at 7 a.m., rose to 51° at 9 a.m., and to 70° at 9.30 a.m., where it remained till 5 p.m., when it fell to 67° on the cessation of the rain. There was a further fall during the night to 57°, the temperature rising to 69° at 9 a.m. on the 16th, which was the maximum for that day.

The general direction of the storm seems to have been from South-south-west, and so far as I can learn it was quite local, the destruction havin

commenced near Ellmau, six miles south-east, and the disturbance having spent its force about as far north-west, doing some damage near Ober-Ammergau. It would seem as if the genius of the Wetterstein had poured his wrath down the precipitous sides of the mountains on this devoted valley. From the lake of Starnberg, about twenty miles north, I learn that although warm for the time of year, and somewhat oppressive, the sky was cloudless and the mountains perfectly clear, showing no signs of such a storm as was raging amongst them.

Plate II. is a rough map of the district showing by arrows the general course of the storm, and the direction in which trees were lying, or that in which roofs were carried from their positions.

The damage caused by the storm is terrible. Being dark at the time I can only speak of our own experience during the height of the storm. The feeling with every one was, "What will go next?" One could see, in the moonlight, fragments of roofs of châlets flying in the air;—my garden was strewed with them, though the nearest châlet was 100 yards off,—also with tiles from my own roof, which was almost bare. Shrubs were stripped of their leaves and nearly uprooted. My transit instrument pillar, composed of brick solidly cemented together, was prostrate; the roof of the offices and out-house was almost bare; the drawing-room window was blown in; the iron fastening was snapped off, and a door to an adjoining room was forced open, the lock being wrenched off—the same happening in the corresponding rooms above. In the adjoining house of a friend a bedroom window, frame and all, with part of the wall was blown in, and the flooring boards of an outlook on the top of the house (each board a good load for two men) were lifted up, and some of them carried seventy yards away.

At daylight a strange scene presented itself. The valley was filled with people searching for and collecting fragments of their châlets, or sitting on the roofs mending them. In the whole length of the valley hardly a hay hut had escaped without being unroofed, and many were carried away bodily. The Government Carving School, a large three-storied house, was stripped of its iron covered roof, which was carried in three huge fragments to a distance of 80, 150 and 300 yards respectively. One half of the wood-work was also lifted off and carried eighty yards before reaching the ground, and lay thirty yards to the right of the first heap of iron roof; a large beam, a foot in diameter, being hurled the same distance and standing upright deeply imbedded in the ground thirty yards to the left of the iron.

Further on a private house, against the garden palings of which lay the third fragment of iron roof, had its upper storey wall under the roof blown in, the opposite wall being blown out; while a large summer drawing-room with iron roof, built out on the south side of the house, was lifted bodily over the house, carrying away the chimney stacks in its progress, and deposited twenty yards off on the opposite side of the house. Another private house just beyond had its roof stripped off, and a summer-house in the garden was carried bodily, with its table and chairs, thirty yards into an adjoining field. There were many other like cases.

In the two villages of Partenkirchen and Garmisch hardly a house escaped without severe damage. In the latter village both church spires were damaged. Between the two villages, only one mile apart, I counted eighty-one prostrate trees, thirty-five of which formed part of the avenue on either side of the road. Perhaps, however, the violence of the storm is better shown by the state of the forests. In every hollow on the mountain sides, no matter what its aspect, the trees fell inwards. Vast spaces are entirely cleared. In one spot on the side of the Eckenberg fifteen large trees lay in a heap, their roots within a radius of twenty yards from where I stood. Further up, the valley becomes very narrow and steep, and though not a tree stands on the side facing the south, those on the opposite side are absolutely unhurt, though standing less than thirty yards from the roots of the fallen ones, whose heads in many cases lay between their stems. By far the worst fate, however, befell the Stangenwald, a wood clothing the precipitous side of the Wachsenstein, at the entrance to the Höllenthal. This faced my window, and on looking towards the place in the morning it was gone. It was about three miles long by one broad, and absolutely not a tree stands. It is estimated by the forester and those accustomed to the forests that 250,000 trees are prostrate in this wood alone.

I visited the wood with a friend, an experienced mountaineer, our aim being to get to the Höllenthal to see if the bridge across the gorge had been carried away, as we meditated an ascent shortly in that direction. It is almost impossible to describe the scene, which must be seen to be realised. We made our way by the river at the foot of the wood to a path which leads across the face of the precipice into the Höllenthal. On the road there, in a part of the wood not very dense, and where we could walk easily, we placed ourselves back to back, with the object of counting the fallen trees within a radius of fifty yards. We counted sixty-three between us, snapped off at ten feet above the ground, and as many more rooted up. This, however, was nothing to what we afterwards saw. We crossed the face of the rock into the Höllenthal to find the path almost carried away by falling rocks at its further end, and the whole side of the valley facing the south a wreck of trees and rocks—nothing standing, while the bridge was much damaged and dangerous.

Afterwards we tried to reach Ober-Grainau by the path which led through the wood (an easy hour's walk). This it took us three hours to accomplish after very laborious work. It was only by going along a tree to its top amongst the cones and dropping to another lying in different direction that we were able to proceed at all. Trees lay in every direction piled one upon another—some snapped off, others torn up by the roots having masses of earth attached six yards in diameter. Huge rocks were lying mixed up with the trees. At one place where I was able to see down through the mass I counted thirteen trunks under the one on which I stood. We eventually effected our exit by dropping down into a gully or timber-shoot, and following this under the trees till we came to the open.

I hear that the destruction is almost as great in the Wambergerwald near Elmau, before referred to.

The forester at Ober-Grainau informs me that the destruction of the Stangenwald took place in a short half-hour, from 7.30 p.m.

The people at Hammersbach, at the foot of the wood, fled in terror to the open, and cried on their knees for mercy, believing that the end of the world was come.[1]

I saw but one squirrel and one deer in the whole wood.

I have to-day read in the *Times* of October 30th an account by Padre Denza, of Moncalieri, near Turin, of a meteoric sandstorm in Northern Italy on the 14th. It would seem, therefore, that our storm was not local, but was the expiring effort of the Italian storm, which reached the south side of the Alps on the night of the 14th, reaching us on the morning of the 15th. This apparently accounts for the "dirty rain." The storm reached the Stelvio, eighty miles south-west of this, at 4 a.m. of the 15th, beginning with hot wind, heavy rain, and lightning. M. F. WARD, *Nov. 3rd.*

NOTE ADDED DECEMBER 7TH.

Since forwarding my report of the storm, I have been over the greater part of the devastated district, and have made every possible inquiry; and I fancy it must have been a local disturbance. I find from the Innthal and the Gurglthal, about thirty to forty miles south-west of this, that although they had heavy and destructive rain they had no wind—nor was there any to speak of at Mittenwald.

The first traces of destruction are at the Ferchensee, three miles from Mittenwald. The lake lies immediately under the eastern precipice of the Wetterstein Range. On the side nearest the mountain every châlet is unroofed, the roofs carried eastward on the opposite side of the lake, and the trees lie in all directions. From that point to Ellmau every tree is down, all lying in the same direction, viz. north-west. On the hill north of Ellmau and facing the valley to the Ferchensee there are three knolls with not a tree standing. On the West of Ellmau, between it and Graseck, in a wood of fine silver firs, masses of huge trees lie in every direction; while others, with

[1] Since writing the foregoing a correspondent writes to a Munich newspaper :—"The late storm has done an immense amount of mischief in the neighbourhood of Ellmau. Here it is almost impossible to pass. The whole of that beautiful expanse of wood, the Unter Hirnschlag, and also a part of the Karlswaldung, was entirely destroyed—not a tree remained standing: trees two feet in diameter were torn asunder in the middle, half remaining standing, the rest being carried away to some distance. Strong trees which have stood several gales were torn up by the roots, the earth being forced up with them, leaving holes ten or eleven yards in diameter. In fact no words can describe the strength of the storm; it must be seen to be comprehended at all. The very lovely wood near Mittenwald was mown down like corn in harvest, trees lying one upon another, their stumps remaining six feet high as standing witnesses of the force of the storm. The Reschbergwald near Forchamt is also very much devastated. The Stangenwald near Ober-Grainau is completely levelled, some 200,000 trees being destroyed. Under the huge mass of trees it is supposed great numbers of deer and other game must be buried."

the exception of a small space entirely cleared, stand unhurt, and from the opposite side of the ravine the wood seems almost untouched. (This wood and that by the Ferchensee are the woods referred to in the communication to the Munich paper mentioned in my report.)

From that point nothing is injured till you get to the valley, with the exception of a few trees on the various ridges. After passing Grainau the storm seems to have turned up a lateral valley of considerable elevation above the main valley, under the Friederspitz, where it levelled some trees, to the Graswang Thal, where it unroofed several houses in the village of Graswang, passed Ober-Ammergau (famed for its Passion Play) without doing any damage, and unroofed the house of the priest in Unter-Ammergau, three miles further. Beyond that I can hear of no damage in any direction.

Between Oberau and Ettal, on the well-known Ettal hill, ascending 700 feet in about a mile, several trees are down—those above the road falling downwards, those below upwards. The ravine which the road traverses is very steep.

The huge Stangenwald, with its large trees and in greater number, seems alone in the greatness of its wreck. I spent two hours in it a short time since to witness the attempt to clear it. In one place, where the trees had been sawn off to clear the road, forty trees lay within a distance of twenty yards, twenty-three lying one upon another in one place.

At the base of the wood, at the foot of a steep grass slope of about 45°, and about 500 feet high, a small wood with a châlet seemed to have been crushed downwards perpendicularly. The tops of trees were still hanging on stumps thirty or forty feet high, while the châlet roof was on the ground inside it, the walls being pressed outwards.

It is calculated that in the entire district comprised in the accompanying map (Plate II.) a million large trees are prostrate.

DISCUSSION.

Dr. MARCET drew attention to the great change of temperature from 31° at 7 a.m. to 51° at 9 a.m., and 70° at 9.30 a.m., being a rise of 39° in a very short space of time. Such sudden changes must be connected with some extraordinary atmospheric phenomenon.

The PRESIDENT (Mr. Scott) said he was very well acquainted with the district, and he proceeded to explain its peculiarities.

Mr. GASTER said that he could not call to mind any month in which the movements of the various depressions which had appeared over Western Europe had been so changeable, and the alterations in their intensity so sudden and frequent, as in October 1885. Some depressions which, when they first appeared, were large and important systems, grew shallower or dispersed before they had been with us more than a few hours; others were formed within the limits of our daily observation, and before they passed outside of those limits had grown into important systems, the full force of which was felt over other parts of Europe. Some of the disturbance came over the British Isles from the West, others from the North-west; one (which advanced from the North-east) grew deeper as it travelled across the North Sea, but on reaching the Wash broke up very suddenly in a few hours. These movements would be shown in the map given as part of the Meteorological Office *Monthly Weather Report* for October 1885, which would shortly appear. Although the storm to which Col. Ward had drawn attention was very local, it was probably connected

with a much larger system, to the movements of which he (Mr. Gaster) would like to draw the attention of the Fellows.

At 8 a.m. on October 14th pressure was high over Russia and Germany and also over the Atlantic, the two high pressure systems being joined by what is now known as a "Col," which lay from East to West over France. To the North of this Col (*i.e.* off our East Coast) lay the last named depression, but to the South of it tranquil weather was generally prevalent (so far as the Mediterranean was concerned), and in most places Northerly to Easterly winds were blowing, and temperature was low generally. The observations in Algeria, however, pointed to the existence of a depression further inland over North Africa; at Biskra the wind was already blowing hard from North-north-west, while a falling barometer and gloomy wet weather showed that the disturbance was advancing Northward.

The system over the North Sea (as already stated) now broke up, but that over Africa advanced Northward with rapidity. The *Bulletino Meteorica* of Rome, and the *Bulletin International* of Paris, for the morning of the 15th, agree in showing that at that time the depression was very large (covering nearly the whole of the Mediterranean), and that its centre lay a little to the westward of the Island of Corsica. Its gradients were much steeper on its North-east side than elsewhere, *i.e.* in exactly those portions which would subsequently pass over Bavaria and Baden. But the effect on temperature was striking,—for while over France, Spain and the Eastern parts of the Mediterranean the winds were more or less Northerly (North-east to North-west), and the temperature remained low (40° to 50° E), those over Italy and the Adriatic were Southerly, and their force violent. Air coming with such rapidity, and straight away from Africa, brought with it the high temperatures of the region whence it was drawn, and the result was that at 8 a.m. on the 15th temperatures of 68° to 75° were prevailing over the more southern portions of the Adriatic and Italy, where on the previous day the thermometer was not higher than 50° to 59°. In the course of the day the depression broke into two portions; one of these moved northwards and reached the neighbourhood of Strasbourg by 6 p.m., where it dispersed; the second (and deeper) portion moved North-westwards, and, travelling along the foot of the Pyrenees, passed away from our area of observation to the Atlantic.

Here, then, was a system of wind circulation advancing rapidly from the region of the Sahara, travelling North, and bringing with it exceedingly high temperatures, to the neighbourhood in which Col. Ward lived. It is only necessary to imagine the formation of a small local subsidiary disturbance near to him (and it has been seen that such phenomena were appearing from time to time in other places) to see that the transference of that heated air and desert sand from the African Continent was a matter of easy accomplishment. What may have been the precise conditions which determined the formation of a squall of such exceptional violence, he (Mr. Gaster) could not say, but the sudden changes of temperature (for in Germany temperatures had been low on the 14th) and the presence of the desert dust seem to be fully accounted for by the facts here quoted.

Mr. GAMBLE remarked that on October 16th the rainfall in the Inn Valley, where he was at that time, must have been very heavy, the river being in an unusually flooded condition.

Mr. SYMONS said that possibly the flood in the Inn Valley referred to by Mr. Gamble might have been the result of the melting of the snow on the mountains, due to the high temperature prevailing.

Col. WARD, who was not present, subsequently sent the following reply to the Discussion:—"With reference to Mr. Gamble's remark, I have ascertained on good authority from Imst, which is situated at the junction of the Inn and Gurgl Thals, that the rain on the 15th October was very great, though entirely unaccompanied by wind. Great quantities of mud and débris were brought down the lateral valleys, literally—in the case of the Gurgl Thal—covering the fields to a depth of one to two feet, thus destroying vegetation and swelling both the waters of the Gurgl and Inn to overflowing. I made no reference in my report to accidents or loss of life, not being then aware whether any had occurred, but there was not an accident of any sort in the whole district, which seems most providential, as the woods at that time of year are full of men, wood labour beginning on the 1st October. They would just have left their work at the time the destruction of the woods began. In the two villages, again, each of which contains from 1,500 300 inhabitants, not an accident occurred either to those in the unroofed s, or to the woodmen or other labourers returning to their several homes."

PROCEEDINGS AT THE MEETINGS OF THE SOCIETY.

NOVEMBER 18TH, 1885.

Ordinary Meeting.

ROBERT H. SCOTT, M.A., F.R.S., President, in the Chair.

THOMAS ROBERT HOOD CLUNN, County Asylum, Prestwich, Manchester;
RICHARD SHEPLEY DAVIES, B.A., 5 Tenison Road, Cambridge;
H. COURTNEY FOX, M.R.C.S., Lordship Terrace, Stoke Newington;
WILLIAM EDWARD JACKSON, Erenkeny, Constantinople;
JOHN RICHARDSON, M.Inst.C.E., F.G.S., F.L.S., Methley Park, Leeds;
ABBOTT LAWRENCE ROTCH, Blue Hill Observatory, Readville, Mass., U.S.A.; and
CHARLES TODD, C.M.G., F.R.A.S., The Observatory, Adelaide,
were balloted for and duly elected Fellows of the Society.

The following Papers were read, viz.:—

"THE HELM WIND OF AUGUST 19TH, 1885." By WILLIAM MARRIOTT, F.R.Met.Soc. (p. 1).

"THE TYPHOON ORIGIN OF THE WEATHER OVER THE BRITISH ISLES DURING THE SECOND HALF OF OCTOBER 1882." By HENRY HARRIES. (p. 10).

"NOTE ON THE PRINCIPLE AND WORKING OF JORDAN'S SUNSHINE RECORDER." By J. B. JORDAN AND F. GASTER, F.R.Met.Soc. (p. 21).

DECEMBER 16TH, 1885.

Ordinary Meeting.

ROBERT H. SCOTT, M.A., F.R.S., President, in the Chair.

JOHN HARTNUP, F.R.A.S., Liverpool Observatory, Bidston, Birkenhead;
ARTHUR WATERS PRESTON, Thorpe Hamlet, Norwich;
RICHARD SHEWARD, 13 Wilmington Square, Eastbourne; and
WILLIAM BARTON WORTHINGTON, B.Sc., M.Inst.C.E., Upwood Mount, Cheetham Hill, Manchester,
were balloted for and duly elected Fellows of the Society.

The following Papers were read, viz.:—

"THE INFLUENCE OF FORESTS UPON CLIMATE." By Dr. A. WOEIKOF, Hon.Mem.R.Met.Soc. (p. 26).

"REPORT ON THE PHENOLOGICAL OBSERVATIONS FOR 1885." By the REV. T. A. PRESTON, M.A., F.R.Met.Soc. (p. 38).

"ETUDES SUR LES CREPUSCULES ROSES." By PROF. A. RICCÒ. (p. 49).

"THE STORM OF OCTOBER 15TH, 1885, AT PARTENKIRCHEN, BAVARIA." By COL. M. F. WARD, F.R.Met.Soc., F.R.A.S. (p. 55).

CORRESPONDENCE AND NOTES.

A Meteorological Phenomenon. By Capt. T. Mackenzie, R.M.S. *Moselle*, Southampton.

Leaving the port of Kingston, Jamaica, at dusk on November 23rd, 1885, the night was fine and star-lit overhead, but about 8 p.m. a heavy bank of cloud obscured the Island, and all around the upper edges of this cloud bank brilliant flashes of light were incessantly bursting forth, sometimes tinged with prismatic hues, while intermittently would shoot vertically upwards continuous darts of light displaying prismatic colours in which the complementary tints crimson and green, orange and blue predominated. Sometimes these darts of light were projected but a short distance above the cloud bank, but at others they ascended to a considerable altitude, resembling rockets more than lightning. This state of matters continued until about 9.30 p.m., when all display of light ceased. As I have never seen such a phenomenon in any other part of the world, I have deemed it an unusual occurrence and worthy of record.

RECENT PUBLICATIONS.

Alpine Winter in its Medical Aspects: with Notes on Davos Platz, Wiesen, St. Moritz, and the Maloja. By A. Tucker Wise, M.D., L.R.C.P., M.R.C.S. Second Edition. 8vo. 1885. viii. + 121 pp. and 8 Plates.

The first edition of this book appeared under the title of *Alpine Winter Cure.* The intention of the author in the present volume is to exhibit the remarkable curative and health-giving properties of Alpine climate in their true light, avoiding exaggeration or an omission of those minor details termed "drawbacks," so necessary to be pourtrayed in the consideration of any foreign or home health resort.

American Meteorological Journal. A Monthly Review of Meteorology, Medical Climatology and Geography. November and December 1885. Vol. II. Nos. 7 and 8. 8vo.

The principal contents are :—The Solar Thermometer, by W. Ferrel (3 pp.).—Determination of Air Temperature (Part 2), by H. A. Hazen (5 pp.). The author has made a comparison of temperatures in an open and in a Wild screen both ventilated and unventilated. He found (1) that in calm weather, the air in the morning has generally a higher temperature in sunshine than in the shade ; (2) that it is possible to obtain the temperature of any spot by the use of the black and bright bulb sling thermometers ; (3) that an open screen, allowing a free natural ventilation and shielding from rain by a slight projection on the inside of each louvre, is calculated to give the best results both of air temperature and humidity ; and (4) that the Wild screen gives too high results during the day hours, though entirely satisfactory as to temperature at night.—On the Relations of Meteorology to Yellow Fever (Parts 2 and 3), by I. H. Stathem (13 pp.).—Notes on the Climate of Detroit, by M. W. Harrington (6 pp.).—The Arago-Davy Actinometer, by W. Ferrel (5 pp.).—The American Nile, by M. W. Harrington (5 pp.).

Annual Report of the Board of Regents of the Smithsonian Institution for the year 1883. 8vo. 1885. xxxviii. + 959 pp.

In the Appendix Cleveland Abbe gives an account of the progress of Meteorology during the years 1882 and 1883 (87 pp.), and also furnishes a list of meteorological publications during that period.

Bulletin of the New England Meteorological Society, Nos. 1-18, November 1884—November 1885. 8vo.

The New England Meteorological Society was formed in Boston, in June 1884, to promote the study of atmospheric phenomena in New England. It issues a monthly Bulletin, which contains a summary of the weather for the month and the results of observations made at 121 stations.

Ciel et Terre. Revue populaire d'Astronomie, de Météorologie, et de Physique du Globe. Deuxième Série—1re Année, Nos. 17-20. November-December 1885. 8vo.

The meteorological articles are:—Les grands tunnels des Alpes et la chaleur du sol (3 pp.).—Quelques remarques sur les marées atmosphériques, à l'occasion du flux solsticial signalé par Baeyer, par F. Folie (4 pp.).

Journal and Proceedings of the Royal Society of New South Wales for 1884. Vol. XVIII. 8vo. 1885.

Contains:—On a new form of Actinometer, by H. C. Russell (2 pp.). This instrument records not only the hours when the sun shines, but also the intensity of that heat.—Water Supply in the interior of New South Wales, by W. E. Abbott (27 pp. and map).—A new self-registering Anemometer and Pluviometer for Sydney Observatory, by H. C. Russell (4 pp.).

Meteorologische Zeitschrift. Herausgegeben von der deutschen meteorologischen Gesellschaft. Redigirt von Dr. W. Köppen. November-December 1885. 4to.

Contains:—Einige Bemerkungen zur Entwickelungs-Geschichte der Ansichten über den Ursprung des Föhn, von Dr. J. Hann (7 pp.).—Der braune Ring um die Sonne bei totalen Sonnenfinsternissen, von Dr. Zenker (7 pp.).—Zur Frage nach dem Ursprung der atmosphärischen Elektricität, von K. F. Jordan (8 pp.).—Ueber die tagliche Periode der Gewitter in Mitteleuropa und einige damit im Zusammenhange stehende Erscheinungen, von Dr. G. Hellmann (13 pp.).—Der vegetative Wärmeverbrauch und sein Einfluss auf die Temperaturverhältnisse der Luft, von C. E. Ney (6 pp.).—Intensitätsmessungen des diffusen Tageslichtes, von Dr. L. Weber (4 pp.).

Montgomeryshire Collections. Vol. XVIII. Part 37. October 1885. 8vo.

Contains:—Rainfall, Temperature and Sunshine in Montgomeryshire, during ten years, ending 1884, by P. Wright (12 pp.). This is a summary of the author's observations at Mellington Hall, Churchstoke, for the ten years 1875-84.

Observations made at the Magnetical and Meteorological Observatory at Batavia. Published by order of the Government of Netherlands India, under the direction of Dr. J. P. Van der Stok. Vol. VI. Part I. 4to. 1885. 358 pp.

This contains the hourly meteorological observations made during 1881 and 1882, and the results for the seventeen years 1866 to 1882. The appendix contains papers on the following subjects:—The Influence of the Moon on the Cloudiness of the Sky (2 pp.).—On Lunar Atmospheric Tide (6 pp.).—On the Relation between the Diurnal Range of the Barometer and the Diurnal Ranges of the Temperature of the Air and the Tension of the Atmospheric Vapour (5 pp.).

Proceedings of the Royal Society. Vol. XXXIX. No. 239. 8vo. 1885.

Contains an interesting paper entitled "The History of the Kew Observatory," by Robert H. Scott, F.R.S. (50 pp.).

Symons's Monthly Meteorological Magazine. Vol. XX. Nos. 238-239. November-December 1885. 8vo.

In addition to the usual information, these Nos. contain the following articles:—The Rainband vindicated, by J. R. Capron (8 pp. and 3 plates). The author

concludes that the fact is established that the little dark "bar" in the yellow of the spectrum can well hold its own in forecast with any other "bars," and that its character has been amply vindicated.—Meteorological Bibliography (2 pp.).

TRANSACTIONS AND PROCEEDINGS OF THE ROYAL SOCIETY OF VICTORIA. Vol. XXI. 8vo. 1885.

Contains:—Experience of the Barque *W. H. Besse* in the Java earthquake, August 1883, by G. H. Ridge (3 pp.). This vessel was on a voyage from Manila to Boston. During the time of the earthquake the shower of ashes was so heavy that they covered the deck to a depth of five or six inches, and the darkness so intense that it was almost impossible to distinguish an object a few inches distant. The barometer fell an inch at once, suddenly rising and falling an inch at a time.—Notes on the Meteorology of the Australian Alps, by J. Stirling (23 pp.).

TRANSACTIONS OF THE HERTFORDSHIRE NATURAL HISTORY SOCIETY AND FIELD CLUB. Vol. III. Parts 5-6. June and September 1885. 8vo.

Contains:—Meteorological Observations taken at Wansford House, Watford, during the years 1883 and 1884, by J. Hopkinson (18 pp.).—Reports on the Phenological Phenomena observed in Hertfordshire during the years 1883 and 1884, by J. Hopkinson (12 pp.).—Report on Insects observed in Hertfordshire during the year 1884, by F. W. Silvester (3 pp.).

ZEITSCHRIFT DER ÖSTERREICHISCHEN GESELLSCHAFT FÜR METEOROLOGIE. Redigirt von DR. J. HANN. Band XX. November-December 1885. 8vo.

Contains:—Anemometrische Studien, von Dr. C. Weihrauch (10 pp.). The first part of the paper deals with the question of the calculation of anemometrical means when less than thirty-two directions are given. The author shows that when the wind is only given to eight points, yet if the velocity be accurately recorded very fair anemometrical results are obtainable, but he still urges on meteorologists the adoption of a reduction to four components. In the second part of the paper he treats of the relation between the mean velocity obtained from the components and the mean of the velocities.—J. G. Gamble über das Klima der Capcolonie (7 pp.).—Wie man aus der Richtung und Drehung der Winde die Aenderungen der Isobarentypen bestimmen kann, von Prof. P. Busin (5 pp.). The author deals with the question of the determination of the type of isobars from wind observations, and states that each change of one isobar type into another produces at each station the same shift of wind. He concludes by saying that he can solve the following problems:—(1) Given two daily observations of wind direction from a district, to determine in advance the type of isobars from day to day; and (2) given the monthly statistics of wind and its shifts, to determine the most frequent types of isobars.—Schirmthermometer in freier Suspension, von Dr. J. Lorenz (3 pp.). This is a proposal which bears some resemblance to Prof. Frankland's suggestion for the observation of radiation. The idea is to fit to the thermometer a small flat shield of white india rubber cloth to keep off the sun's rays from the bulb and tube. If radiation from the ground is to be feared a frame covered with similar cloth is to be placed under the thermometer. The whole apparatus is to be placed in the open air shortly before each observation. Dr. Lorenz remarks that the heating of the screen cannot influence the thermometer readings.—Der säculare Verlauf der Witterung als Ursache der Gletscherschwankungen in den Alpen, von C. Lang (15 pp.).—Ueber den Temperaturunterschied zwischen Stadt und Land, von Dr. J. Hann (5 pp.).—Ueber das Klima am Congo und an der SW-Küste von Africa überhaupt, nach Dr. A. v. Danckelman (9 pp.)—Die tägliche Periode der Richtung und Geschwindigkeit des Windes auf Berggipfeln, von R. Billwiller (7 pp.).—H. Mohn: Klima von Norwegen (8 pp.).—Veränderlichkeit einiger meteorologischer Elemente von einem Tage zum anderen zu Budapest 1873-1882, von Hegyfoky (12 pp.).—Ueber die Vertheilung des Regens in Niederländisch-Indien 1841-1883, von V Raulin (4 pp.).

QUARTERLY JOURNAL

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VOL. XII. APRIL 1886. No. 58.

CLIMATOLOGY OF THE SEA.—AN ADDRESS DELIVERED AT THE ANNUAL GENERAL MEETING, JANUARY 20TH, 1886. By ROBERT H. SCOTT, M.A., F.R.S., President.

ON the former occasion on which I had the honour of addressing you as your President, my subject was the Climatology of the Globe, and more especially of that part of it which is dry land. It may perhaps interest the Fellows this evening if I say a few words on the Climatology of the Sea.

It is possibly within the recollection of a few who are present that nearly ten years ago (May 17, 1876) I read a paper, *Remarks on the Present Condition of Maritime Meteorology*, which was honoured by being printed in Vol. III. of the *Quarterly Journal*. Now a considerable space of time has elapsed since that paper was read, and as this period has been more or less prolific of investigations relating to the meteorology of the sea, I propose to notice briefly the most important of these researches.

In the first place, I find in that paper notices of certain investigations which were in 1876 openly contemplated, if not actually commenced; and it is interesting to note what has been heard of these in the succeeding nine years.

On the part of the Meteorological Office, the discussion of the meteorology of the six Ten-Degree Ocean Squares lying about the south point of Africa had at that time been commenced, and has since been published. This work presents some features of novelty, and I shall therefore presently return to its consideration.

It was further announced that the Indian Government had applied for a

copy of all the observations existing in the Meteorological Office for the Indian Ocean north of the Equator, and that information has since been supplied to Mr. Blanford.

In the way of international co-operation, the fact was mentioned that the Meteorological Institutes of Utrecht and Hamburg had undertaken to discuss the existing materials for the China Sea and for the Atlantic Ocean between 20° and 50° N lat. respectively, the two offices undertaking to interchange their data.

Of these investigations all that has hitherto seen the light has been the information for five ten-degree squares in the Atlantic, being those from 10° to 30° W and from 50° to 20° N; the squares lying on the direct track from the Channel to the Equator.

The German Office, however, has published an *Atlas of the Atlantic Ocean*, as illustrating its sailing directions (*Segel-Handbuch*) for that region. This work does not make any claim to represent exclusively original data, but like the *Wind and Current Charts* of our own Admiralty, it is a compilation from all available publications of merit, supplemented by original material from the stores of the Seewarte.

In 1876 Lieut. Brault had already commenced the issue of his Wind Charts, to the consideration of which I shall return again; but I must here express the feelings of profound regret with which the announcement of his early death was lately received by all who knew him or his works. Lieut. Brault had contracted serious hepatic derangement during service in tropical waters, and even as early as at the Congress of Rome in 1879 was suffering gravely from its effects. He still, however, struggled on manfully, and succeeded in publishing his Wind Charts for all the oceans before his death in August last. The French Academy awarded to him in 1881 a moiety of the "Prix extraordinaire destiné à recompenser tout progrès de nature à accroitre l'efficacité de nos forces navales."

Our own work on the meteorology of the Cape of Good Hope must first be noticed. It presents some features of novelty as compared with previous publications, inasmuch as in it the materials have been subjected to a process of "weighting," which I shall now proceed to describe briefly.

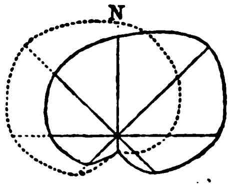
To explain the reason why this novelty has been introduced, I cannot do better than quote the words of my colleague Capt. Toynbee:—"There can be no doubt that observations at sea are much affected by the speed of the ship, more especially in those parts of the sea where ships' tracks usually lie in one direction. * * * In the part of the sea which lies near the Cape of Good Hope the tracks of nearly all ships bound to the eastward will be found to lie to the Southward of 38° S, while the tracks of nearly all ships bound to the westward will be found to lie to the Northward of 36° S. Hence Westerly winds will carry the "outward bounder" quickly through a given space of the sea which lies to the southward of 38° S, while Easterly winds will check her progress and keep her longer recording observations, in that space. To the northward of 36° S this rule will be reversed, and Westerly winds will

detain the "homeward bounder" longer in a given space of the sea, while Easterly winds will carry her quickly through it. If we were to employ the method of giving an equal weight to each observation, the result would be that an undue weight would be given to Westerly winds to the northward of 36° S, and to Easterly winds to the southward of 38° S."

The diagram (Fig. 1) shows the practical effect of the ship's different tracks on the resulting windroses for a single square degree lying off the Cape of Good Hope. The full line shows the windrose and resultant, S 26° W (force 2·0), yielded by giving an equal weight to each observation;

FIG. 1.

Wind Drift



Scale ¼ inch-1 of Beaufort's Notation

Full line (equal weight to each observation)	Resultant	= S 26° W.	2·0
Dotted " (" " ship)	"	= S 31° E.	2·3

the dotted line the windrose and resultant, S 31° E (force 2·3), yielded by giving an equal weight to each ship. The least reflection will show the Fellows that the latter result is more likely to be correct than the former. The same principle is of course applicable to observations of the barometer, and in fact to all data relating to weather.

As a ready though only approximate method of arriving at a true result, the plan was adopted of admitting no more than a single observation from the same ship on the same day, and in the same one-degree square: the mean being taken when the ship had made many observations on the same day in the same square. The observations being at four-hourly intervals, it is only with very unfavourable winds that a ship would record more than two or three observations in a single one-degree square.

It is a remarkable fact that none of the foreign meteorologists whom we consulted, men of great experience, would recognise the desirability of this weighting process, and accordingly the wind results for the Cape District which we have published are not comparable with those which have appeared elsewhere.

There is, however, another point of novelty connected with the Cape discussion which may possibly interest the Fellows. The observations have been grouped together, not for the ordinary five or ten-degree squares, but for homogeneous areas. The monthly means being originally taken for single-degree squares, the results were carefully compared together, and if a number of these, lying close to each other, were found to agree *inter se* in

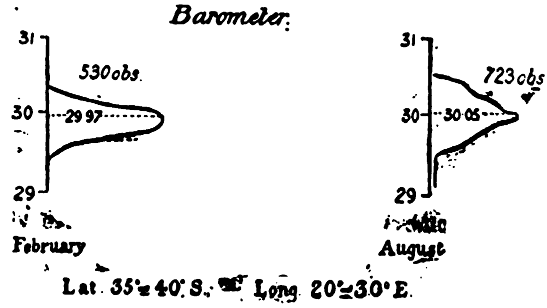
the general distribution of their results, the squares were thrown together and a general mean was taken.

Some such principle of rational grouping had been proposed more than twelve years ago by Professor Buys Ballot in his *Sequel to the Suggestions on a Uniform System of Meteorological Observations*, but as yet it is only our office which has followed the Professor's lead (in his *North Atlantic Wind Charts* 1877).

There is yet another novelty in the mode of representation of barometrical results. It was found that the use of the ordinary system of exhibiting the distribution of pressure, by isobars, conveyed a very imperfect idea of the state of affairs, as all the phenomena of range are entirely masked when the bare mean results appear.

Diagrams of barometrical frequency are therefore used, and I have reproduced some of these on an enlarged scale (Fig. 2). The scale on the left

FIG 2.



represents that of the barometer, and the ordinate of the curve at any scale reading is proportionate to the percentage frequency with which the barometer has been observed to stand at that particular height. The area enclosed by the curve is therefore approximately constant in all cases, so that the ordinates of the different curves may be compared with each other, and the relative frequency with which the barometer stands at each individual height in different parts of the district may be learnt at a glance.

A similar plan has been adopted for the specific gravity of sea water.

As soon as this investigation of the region lying near the Cape of Good Hope had been completed, the main attention of the Office was temporarily diverted from what I may call the climatological branch of marine meteorology to the prosecution of weather study, as the Fellows must be fully aware, from the circumstance that our forthcoming Atlantic Weather Charts have been repeatedly mentioned at the meetings.

There is, however, another independent series of charts emanating from the Office, and these, I may be allowed to say, indicate a return to the plan of treatment of oceanic data at first followed by Admiral FitzRoy, of dealing with the several elements separately.

These charts have been drawn by Lieut. Baillie, who in their preparation

has utilised not only our logs and the logs and remark books of the Royal Navy, but also the published records of various voyages of discovery, under whatever flag these had been carried on. In the *Charts of Sea Temperature* which are published, and in those of *Barometrical Pressure*, which are in the engraver's hands, few available records go back further than half a century, for the simple reason that the quality of the old instrumental outfit of a ship does not come up to modern requirements. In the *Charts of Ocean Currents*, which Mr. Baillie is now commencing, the sources of material are far more copious, inasmuch as every log of a ship, which was correctly navigated will yield good Current observations.

It should be pointed out that the pressure charts are accompanied by a set of index charts on a smaller scale, showing the amount of barometrical range, and thus indicating to the seaman within what limits the readings he may obtain in each district may be expected to vary.

The next publications which I have to notice are those of Lieut. Brault, and they comprise a series of charts for the four oceans—Atlantic, North and South, Indian and Pacific. These are sixteen in number, in four sets, one for each quarter of the year. In this respect they resemble the *Pilot Wind and Current Charts* of our own Admiralty. M. Brault contemplated, if he had been spared, to have supplemented these charts by a set of sixteen others, showing Currents and other meteorological phenomena, and ultimately to have issued a series of monthly charts. These charts give not only the direction, but also the force of the wind, and M. Brault was able, for certain oceans at least, to draw *isanemones*, or curves of equal wind-force, which, as might be anticipated, coincide very generally with the isobars.

These charts were not, however, as our neighbours across the Channel maintain, the first charts of wind-force; for the charts of ocean statistics in five-degree squares, of which the issue was commenced by Admiral Fitz-Roy, although but a few appeared for the North Atlantic, also gave information as to wind-force. The materials for these statistics were obtained from the logs accumulated by the Office, at that time in its comparative infancy. Subsequently, in the charts for Nine Ten-Degree Squares, which appeared in 1875, the wind-force was duly noticed.

All these charts had appeared before Lieut. Brault had published anything, but it must be admitted that he was the first to exhibit charts of wind-force for the whole globe. It is, however, greatly to be regretted that his charts are for three-monthly periods, so that any change which may take place between the first and last of the months is comparatively masked. This defect would have been removed if the charts had referred to the central months of the four seasons as types.

The next series of charts to be noticed are those emanating from the Dutch Institute, and these are mainly wind charts. The area taken up is the Atlantic Ocean, North and South, and this is fully dealt with excepting the belt from 14° to 26° S, the heart of the South-east Trade Wind. The extent of longitude covered by the charts varies according to the ship tracks, for the information furnished by the Dutch ships refers mainly to the tracks from the Straits of Sunda to the coast of Holland.

The charts give monthly windroses for single degree squares, and in addition quarterly windroses for rational areas, which are not by any means the same in all the charts, but are selected according to the distribution of materials.

The Dutch have also published two sheets showing the mean barometrical pressure for the Atlantic; these sheets really show the data for monthly barometer windroses to sixteen points of the compass, and for strips of 5° of latitude. The strips vary in width from 30° of longitude off the coast of Portugal to only 10° at the Cape of Good Hope, but preserve an average width of twenty degrees from the parallel of 35° N to the Equator. They stretch from 25° to 45° W in 35° N, and from 15° to 25° W on the Line. It will be seen from these figures that the region to which the data refer is limited by the usual homeward bound tracks of ships, and is far from covering the whole extent of the ocean.

My notice of European marine work, however, would be far from complete were I not to mention the work first begun by the lamented Capt. Hoffmeyer, of charting the weather over the North Atlantic. This is now being carried out on the lines laid down by him by Dr. Neumayer at Hamburg, and by Dr. Paulsen, Captain Hoffmeyer's successor at Copenhagen.

Of the original series Capt. Hoffmeyer published charts for 3¼ years, September 1873 to November 1876. And of the series now in progress, the charts for fifteen months, from December 1880 to February 1882, have already seen the light.

Of special investigations in connection with ocean meteorology, I must not omit to mention the discussion of the *Challenger* results by Mr. Buchan, and the completion of the Norwegian Atlantic Expedition in the *Voringen* in the summers of 1876-8.

This latter expedition is the only instance on record of a series of meteorological observations at sea, made under the personal supervision of an experienced meteorologist (our honorary member Professor Mohn), who himself has subsequently discussed and published the results. A portion of these results were laid before this Society in 1878 by Prof. Mohn, and appear in Vol. IV. of our *Quarterly Journal*; but the complete volume, which appeared in 1883, is a perfect treasure-house of experiments on the various modes of conducting observations on the several phenomena embraced under the term Maritime Meteorology.

Leaving the Old World we now come to see what is being done in the New, where some thirty years ago the foundations of our knowledge of ocean meteorology were laid by Maury. The United States Naval Observatory has given up meteorology, and the Coast Survey is now devoting its attention mainly to geodesy and land surveying; the Hydrographic Office at Washington has, however, taken up actively the study of ocean meteorology, which had been somewhat in abeyance since the war.

Two series of charts for extensive areas have appeared. The first was published in 1878, and it refers to the North Pacific Ocean as far as the meridian of 180° W, and the parallel of 45° N. The second appeared in 1883, and covers

the North Atlantic. In each series of charts the mean values for each element are given numerically for five-degree squares, but no graphical representations have been issued excepting some for the whole year, which naturally have but little value compared with similar charts for individual months.

For the last two years the Washington Hydrographic Office has taken a fresh departure, with its Pilot Charts for the North Atlantic. These appear monthly, and it is announced that we are to expect a weekly issue hereafter. They give mean results for the current month, with extracts from logs as to remarkable experiences during the month which has preceded it. Thus, for instance, the chart for December 1885 exhibits Maury's mean figures for December, and in addition the reports of ice, derelict ships, waterspouts, whales, &c. which have come in for the November just preceding. This is a most important undertaking, but its successful prosecution can only be expected where a liberality such as that of the Washington Government enables the publishing office to place a copy of the very latest edition of the chart for each particular month in the hands of each captain leaving a port.

What are then the prospects of Marine Meteorology at the beginning of 1886? In our own Office the task of preparation of the *Daily Atlantic Weather Maps* for the year of circumpolar research is completed, and the stage of engraving the results has been reached. This may be expected to last more than a year.

Of other investigations of a similar nature I may say that our honorary member, Dr. Neumayer, has undertaken, for the same interval of time, the preparation of *Daily Charts for the South Atlantic*, a perfectly novel and very promising field of investigation, for no attempt has yet been made to throw light on the weather prevailing off the Rio de la Plata and the coast of Patagonia.

For the Indian Ocean Dr. Meldrum is still engaged with his charts for the year 1861, of which we may shortly expect a further instalment. The Chief Signal Office, Washington, is of course continuing its *International Charts*, but as these mainly depend on land observations, they do not come directly under my notice this evening.

Of new work, dealing exclusively with observations made at sea, we ourselves have taken up the study of the Red Sea meteorology; but this area is so limited that the discussion must speedily be brought to a close, and no other inquiry of a similar nature is as yet in contemplation.

The proposed preparation of *Monthly Current Charts* is an important undertaking, and one which may be expected to occupy a considerable interval of time. The idea of monthly charts commends itself to every one who really considers the subject. An annual chart can make no pretence to represent seasonal changes in currents, if such exist, and to take four months as typical of the seasons is a step, but only one step, in advance. In the progress of discussion of monthly data, we may fairly hope that interesting facts as to the periodical changes in currents will come to light, and that many of the theoretical generalisations as to marine circulation will be brought face to face with a solid array of facts.

On the Continent the only new inquiry which has been formally announced is one relating to the Indian Ocean. The Meteorological Institute of the Netherlands contemplates the preparation of an *Atlas for the Indian Ocean*, after the model of that for the Atlantic published by the Deutsche Seewarte. As regards the northern portion of that ocean, the Indian Meteorological Office, under Mr. Blanford, has obtained for discussion a copy of all the materials existing in our hands, so that we may expect that this region, at least, will be very thoroughly dealt with.

The Pacific, however, still remains a practically unknown sea. The Hydrographic Office, Washington, has, as I have said, published charts of data for the north-eastern portion, but no attempt at an exhaustive discussion has been made even of this region.

We may now at last begin to think that a good time is coming. The Transpacific passenger trade to San Francisco from the Australian Colonies and from China is daily increasing in magnitude, and observations from those routes cannot fail to come in, if not to this country, at all events to the United States. We may, however, anticipate that ere long we shall have lines of steamers to British ports on the Pacific coast. The completion of the Canadian Pacific Railroad, which brings Vancouver Island within ten days of England, has brought China nearer to Europe than it is even by the Suez route. As regards India, the time occupied is about the same by the East or by the West, while the latter route offers one advantage which may possibly have weight, that, while the sea is free to all, the entire land portion of the journey is within the limits of our own territory, and does not call for perpetual anxiety, if not actual warfare, to ensure the safety of our communications.

These considerations must, sooner or later, come to the front, and then the Pacific Ocean will have a chance of remaining no longer a region meteorologically almost unexplored, and our knowledge of the atmospheric conditions of the accessible oceans of the globe will make some claim to completeness.

REPORT OF THE COUNCIL

FOR THE YEAR 1885.

THE Council are glad to report that the year now closing has been one of almost unexampled activity, for at their first Meeting in February no less than seven separate Committees were appointed, viz.—

GENERAL PURPOSES COMMITTEE:—The President, Secretaries, Foreign Secretary, Treasurer, Mr. Ellis, Mr. Latham, Mr. Laughton, and Mr. Lecky.

EDITING COMMITTEE:—The President, Mr. Inwards, and Mr. Whipple.

ANNUAL EXHIBITION COMMITTEE:—The President, Secretaries, Mr. Lecky, Strachan, and Mr. Whipple.

INTERNATIONAL INVENTIONS EXHIBITION COMMITTEE:—The President, Secretaries, Mr. Lecky, and Dr. Marcet.

EXPERIMENTAL RESEARCH COMMITTEE:—The President, Mr. Archibald, Mr. Benn, Mr. Eaton, Mr. C. Harding, Mr. Laughton, Mr. Russell, Mr. Symons, and Mr. Whipple.

DECREASE IN WATER SUPPLY COMMITTEE:—The President, Mr. Chatterton, Mr. Latham, and Mr. Symons.

NEW PREMISES COMMITTEE:—The President, Secretaries, Mr. Chatterton, Mr. Dyason, and Dr. Williams.

In June an Eighth Committee was nominated, viz.:—

WIND FORCE COMMITTEE:—The President, Mr. Archibald, Mr. Chatterton, Mr. C. Harding, and Mr. Laughton.

The whole of these Committees have met frequently and have done much for the advancement of meteorology as will be gathered from the following brief notes on their work.

The usual Annual Exhibition of Instruments was held on March 18th, at the Institution of Civil Engineers, and was kept open till March 20th. There were eighty-four exhibits, a complete list of which will be found in the *Quarterly Journal*, Vol. XI. p. 242.

At an early meeting, the Council took into consideration the continuance of the Climatological Station at the International Inventions Exhibition, and the preparation of a short Pamphlet for distribution. They decided to modify the Pamphlet which was distributed at the Health Exhibition, and to add a list of Meteorological Instruments invented since 1862. A copy of this Pamphlet was forwarded to the Fellows in July. The Jury Commission has awarded to the Society a Diploma of Honour for its Meteorological Station. The instruments were removed at the close of the Exhibition, so that the observations taken in the grounds of the Exhibition have now ceased.

Considerable progress has been made with the Helm-Wind inquiry by the Experimental Research Committee, who have collected a large amount of information on the subject, and have presented a Report on the occurrences of the Helm-Wind from 1871 to 1884, which was read at the April Meeting of the Society.[1] In order to further investigate the matter, the Committee considered it desirable that thermometrical and hygrometrical observations should be obtained from the neighbourhood. Before starting the observations, the Council requested their Assistant Secretary, Mr. Marriott, to visit the district and to make inquiries on the subject. This he did in August, and was fortunate enough to witness the phenomenon of a slight Helm, an account of which was read at the November Meeting.[2] The Penrith and District Literary and Scientific Society has taken great interest in the matter, and a number of its members have arranged to go out into the neighbourhood of Cross Fell when the Helm is on and make observations on each side of and beneath the Bar, as well as at various places in its vicinity. The co-operation of a number of observers at fixed stations has also been enlisted. As,

[1] Vol. XI. p. 226. [2] Vol. XII. p. 1.

for this purpose, several instruments will be required, your Council made application to the Meteorological Council for the loan of such, which has been readily granted. A Richard Thermograph has also been placed at the disposal of the Committee by the Hon. Ralph Abercromby. The Council have to acknowledge the valuable assistance which Mr. T. G. Benn, of Newton-Reigny, has rendered them in the Helm-Wind inquiry.

A Report from the Decrease of Water Supply Committee was read at the April Meeting of the Society.[1] A considerable amount of data had been received, but as the Council deemed it insufficient, it was decided that when the Report was printed in the *Quarterly Journal*, a circular should be issued to the Fellows inviting communications on this very important subject.

The reference to the New Premises Committee was a request to seek for new Premises, at an annual rental of not more than £150, inasmuch as the present rooms are found to be rather inconvenient for the Library and extended work of the Society. The Committee reported that they had met with only one set of rooms which was at all suitable; and for three rooms near Great George Street, on the ground floor, at the back, the sum of £150 per annum was asked. The Committee advised the Council that they did not recommend these premises to be taken, as the rent was too high, and the rooms would not afford sufficient light for the work of the Society. The Council adopted this Report.

The Wind Force Committee was appointed to investigate the relation between Beaufort's Notation of Wind Force and the equivalent velocity in miles per hour, as well as the corresponding pressure in lbs. per square foot for each grade of the scale. Also to inquire whether or not any existing scale can be adopted or modified; and if not, to determine what equivalents can be recommended for general and international use. Lastly, to report on the best mode available for the attainment of a satisfactory solution of the entire question. Sufficient time has not yet elapsed for a report on this difficult subject; but it is to be hoped that when received and discussed, some approach to uniformity will be attained.

A Bill was brought into the House of Commons by Sir Charles Dilke and the Attorney-General (Sir H. James), termed the "Corporate Property Security Bill," to prevent the members for the time being of any scientific Society, not being an association formed for trading purposes, from determining the existence of such Society, or dividing its property, except with the consent of one of Her Majesty's Superior Courts. As the Council were of opinion that this Bill would unduly limit the powers of this Society, they prepared a Petition against the Bill under Seal, which was presented on April 21st by Mr. P. Phipps, one of the Fellows, to the House of Commons. The Council pointed out in their Petition, that, subject to certain restrictions contained in the Charter, they have, on behalf of the Society, full power to dispose of the *corpus* and income of all property, whether real or personal, belonging to the Society; and they considered that the Bill would not only

[1] Vol. XI. p. 216.

unduly restrict the powers of the Society, but augment the difficulty of carrying on this and other learned Societies. The Petition will be found printed in Appendix III. p. 82. The Bill was opposed by many other bodies, and did not become law.

A letter was received from the International Meteorological Committee, announcing that the General Meeting would be held in September at Paris, and inviting suggestions for consideration and discussion. The Council requested the International Committee to decide upon the following questions:—(1) A Standard Velocity Anemometer; and (2) The general adoption of a uniform height for Anemometers above the ground. A reply has been received to the effect that, in the opinion of the International Committee, the questions are too complex, and have not yet been sufficiently studied to arrive at a resolution.

The Society's Stations in the North and East of England have been inspected by Mr. Marriott during the year, and were found to be in a satisfactory state. The thermometers had undergone less change than at the former inspections; but in a few cases some spirit was discovered at the top of the tube of the minimum thermometers. As this is one of the most frequent causes of error in temperature observations, the particular attention of observers is directed to it. It was also found that in two instances the divisions on the thermometer tubes and those on the porcelain scales did not agree, causing risk of erroneous readings. The Report also points out the advisability of a cap being placed over the receptacle for water used for the wet-bulb, so as to prevent evaporation and keep the water clean. Mr. Marriott also took photographs of the stations, which have been placed in the Society's Album, thus forming a valuable and interesting record of the Stations and their surroundings. The Report will be found *in extenso* in Appendix I. (p. 77). There have been some slight alterations in the list of stations during the year, returns having been accepted from Bennington (Herts) and Ushaw (Durham), whilst those from Leaton (Shropshire), Throcking (Herts) and Tunbridge (Kent) have been discontinued. The total number of stations is eighty-one, there being twenty-five Second Order and fifty-six Climatological Stations.

The Meetings of the Society during the past Session have been well attended, and the speakers numerous, so that there has been often a difficulty in concluding the business within the usual time. The number of Papers read has been twenty-five, and among these an unusual proportion has been furnished by the Honorary Members, especially by Dr. W. Köppen and Dr. Woeikof, each of whom has contributed two.

The *Meteorological Record* continues to be printed and circulated as usual, but with the commencement of the New Year it will be reduced in size. The Quarterly Returns of the Registrar-General will, for the future, be issued with it, instead of forming part of the *Quarterly Journal*, so that the publication of the latter may not be delayed.

The Council have drawn up a list of the rules under which Papers are accepted by the Society. The most important of these rules refer to the

property of the MSS., Diagrams, and Charts sent to the Society, and the cost of authors' corrections. The Secretaries are also empowered to refuse Papers which are not properly prepared. These rules will be found in Appendix II. p. 81.

The Library has received a full share of attention, nearly £40 having been expended in the purchase of books and in binding. A large number of publications of various kinds has been received in exchange for the copies of the *Journal* and *Record* sent to various Public Institutions and Scientific Societies in different parts of the world. In addition to these several important works have been presented to the Society by individuals. A list of the donations received during the year will be found in Appendix VII. (p. 87). The numerous applications received by the Council for an exchange of publications are an indication of the esteem in which the labours of the Society are held.

The Society has to deplore the loss by death of eight Fellows:—

Rev. William R. C. Adamson	elected in the Society	February 21st, 1883.
N. St. B. Beardmore, M.Inst.C.E.	" "	June 18th, 1873.
William Gough Birchby	" "	February 15th, 1882.
Lieut.-Col. G. E. Bulger, F.L.S.	" "	March 15th, 1876.
James Deane	" "	December 17th, 1873.
Samuel Forrest	" "	February 18th, 1880.
Major Fermor B. Gritton	" "	March 15th, 1876.
William Jones Loyd, M.A.	" "	January 15th, 1879.
Rev. F. Redford, M.A., F.R.S.E.	" "	November 27th, 1855.
Cornelius Walford, F.I.A., F.S.S.	" "	March 21st, 1883.

The number of Life Fellows on the roll of the Society is 135; of Ordinary Fellows 381; and of Honorary Members nineteen, thus making a total of 535, being a decrease of sixteen on the year.

The following table exhibits the changes which have taken place in the number of Fellows during the year:—

Fellows.	Annual.	Life.	Honorary.	Total.
1884, December 31 ...	395	137	19	551
Since elected	+20	0	0	+20
Deceased	− 8	− 2	0	−10
Retired	−23	0	0	−23
Defaulters	− 1	0	0	− 1
Lapsed	− 2	0	0	− 2
1885, December 31 ...	381	135	19	535

At first the Balance Sheet appears unsatisfactory, as the balance brought forward from last year was £196 9s. 9d., whilst that at the end of the current year it was only £155 7s. 3d., showing a deficiency of £41 2s. 6d.

Several items which are found under the heading of Expenditure will, however, not recur during next year, viz. £81 15s. 0d. invested for sums received from compounding Fellows in 1884; an excess of above £40 for printing and illustrations for the *Quarterly Journal;* of about £10 for Forms for Observations, &c.; and about £25 for expenditure in connection with the International Inventions Exhibition; making a total of £106 15s. 0d. The Meteorological Council has made its usual annual grant of £25 towards the expenses incurred in the Inspection of Stations, and the ordinary payments for copies of the Weekly, Monthly and Annual Returns from the Society's observers.

The foregoing figures are, however, sufficient to show that if the Society is to be maintained in its present position of activity, the Fellows must make strenuous efforts to induce such of their friends as are suitable to join its ranks. If each could introduce one new Fellow during the year no more would be heard of a reduced balance to credit, and the Society would be enabled to enter boldly into more than one field of research from which it is now debarred by considerations of necessary and judicious economy.

APPENDIX I.

Report on the Inspection of the Stations during 1885.

The stations in the North and East of England have been inspected during the year, and found to be generally in a very satisfactory condition. 168 thermometers have been tested, and the result showed that less change has taken place since the previous comparison than had been found on former occasions. In a few cases spirit was discovered at the top of the tube of the minimum thermometer. This is a common source of danger; and observers should always be on the look out for the first appearance of spirit at the top of the tube.

In two instances the divisions on the thermometer tube did not agree by 1° with those on the porcelain scale, the tube having slipped. When such is the case, the observers are apt to get into the habit of looking at their thermometers sideways, and consequently obtain an erroneous reading.

The muslin and cotton round the wet-bulb thermometers were generally in good condition, except at about three stations, where the muslin was nearly dry. It is desirable that a cap or cover with a small hole in it should be placed over the top of the water receptacle, as this would prevent evaporation and also keep the water clean.

The thermometer screens in several instances required painting.

I beg to submit photographs of all the stations inspected, which are mounted in the Album along with those taken last year. These photographs now form a valuable and interesting series of pictures, showing the exposure and surroundings at the various stations.

William Marriott,

October 6th, 1885, Assistant-Secretary.

NOTES ON THE STATIONS.

ALSTON, *August 20th.*—This station was in good order. The maximum and minimum thermometers were found to be reading too low by 0°·4 and 0°·3 respectively.—*Observer*, T. W. DICKINSON.

ASPLEY GUISE, *September 18th.*—This station was in good order. A new pattern thermometer screen has been obtained and is in use. The shrubs and trees to the west are growing very rapidly, so that it will be necessary shortly to remove the rain-gauges further to the east. The thermometers were all correct except the minimum, which had 0°·5 of spirit at the top of the tube. The sunshine recorder has been removed from the lawn and placed on a tower which has been added to the house.—*Observer*, E. E. DYMOND, J.P., F.R.Met.Soc.

BELPER, *September 1st.*—The thermometers were found to be correct. The thermometer screen required painting. The exposure is very confined, being much enclosed by trees. The rain-gauge, which is in a lower part of the town, was very much protected by trees on the south-east and north-north-east. The observer was requested to have it removed to a more open situation.—*Observer*, J. HUNTER, F.R.Met.Soc.

BENNINGTON, *September 17th.*—This station, which is nearly midway between Buntingford, Stevenage and Ware, is on the highest ground in the whole of the district, which is of a very undulating nature. The instruments are placed in an extension of the lawn in front of the house, the ground sloping to the eastward. Every thing was in good order. None of the thermometers except the maximum and the grass minimum had Kew certificates.—*Observer*, REV. J. D. PARKER, LL.D., F.R.Met.Soc.

BLACKPOOL, *August 28th.*—Every thing at this station was in a satisfactory condition. The sunshine recorder, anemometer, and sea thermometer are at the end of the North Pier. Dr. Welch, the Medical Officer of Health, has charge of these instruments and has also a Stevenson screen close to the beach, which will, however, be removed to a more suitable position.—*Observer*, C. T. WARD, M.A., F.R.Met.Soc.

BOLTON, *August 29th.*—The instruments were in good order, the recommendations made at the last inspection having been carried out. A new pattern thermometer screen has been obtained. The observer has also a Richard barograph. [Mr. Mackereth was obliged to discontinue the observations on December 31st, 1885.] —*Observer*, REV. T. MACKERETH, F.R.Met.Soc.

BOSTON, *July 30th.*—The instruments were in fair order. The Officers of the Ordnance Survey had erected a platform on the top of the tower of the church, and at the time of my visit masons were engaged in repairing the pinnacles. The outer screen round the electrical thermometer had been temporarily taken down.—*Observer*, G. E. HACKFORD.

BUXTON, *September 1st.*—The thermometers were correct except the grass minimum, which had some spirit at the top of the tube. The thermometer screen required painting, and the rain-gauge to be firmly fixed and made quite level. The observations have been under the superintendence of Dr,

Thresh since January 1st, Dr. Sykes having left Buxton at the end of 1884.—*Observer*, Dr. J. C. Thresh.

Cheadle, *August 31st.*—The thermometer screen required painting, and also strengthening to prevent oscillation in windy weather. The barometer had been sent to the maker to be cleaned and to have a wooden case made for it, an aneroid being used in the interval. The observer was requested to move the rain-gauge further to the north-west, so as to make a smaller angle with the tree on the south-east.—*Observer*, J. C. Philips, J.P.

Cramlington, *July 25th.*—On comparing the thermometers it was found that the minimum read 0°·4 too low. The thermometer screen required painting. The rain-gauge had been removed to the more open site selected for it at the last inspection.—*Observer*, W. Bonallo, F.R.Met.Soc.

Cromer, *August 13th.*—As the bulbs of the thermometers were only 3ft. 6ins. above the ground, and the door of the Stevenson screen opened to the east instead of the north, the observer was requested to have the screen raised to 4ft. and turned so that the door shall open to the north. It would be more satisfactory if grass were laid down under the screen, and if no shrubs allowed to grow round it.—*Observer*, J. Cooper, F.R.C.S.

Finchley, *September 24th.*—The instruments were in the same position as at the last inspection. The thermometer screen was very dirty and urgently required painting. I was informed that the instruments would be removed in the course of a few weeks to the site selected for them last year. A new rain-gauge will be obtained, the present one having leaked in the funnel and been repaired.—*Observer*, H. C. Stephens, F.R.Met.Soc.

Hillington, *August 14th.*—The thermometers were all correct. The observer was requested to have overlapping boards put at the bottom of the screen, and also a louvre on each side of the screen, where it is at present wanting. The sunshine recorder is now placed on the top of the house, the only object likely to affect it being the chimney on the west-south-west to west.—*Observer*, Rev. H. E. B. Ffolkes, M.A., F.R.Met.Soc.

Hodsock, *September 3rd.*—Every thing at this station was in good order. In addition to a full set of instruments the observer has a Richard barograph and an electrical anemometer.—*Observer*, H. Mellish, J.P., F.R.Met.Soc.

Kenilworth, *September 19th.*—The observer was away from home at the time of my visit, but the gardener was in charge of the observations. On examining the thermometers it was found that there was a considerable amount of spirit at the top of the grass minimum. The thermometer screen required painting.—*Observer*, T. G. Hawley, F.R.Met.Soc.

Lowestoft, *August 12th.*—This station was in good order. On comparing the thermometers it was found that the zero of the maximum had risen 0°·3. It was proposed in the course of a few months' time to enlarge the garden, which will improve the exposure of the instruments.—*Observer*, S. H. Miller, F.R.Met.Soc.

Macclesfield, *August 31st.*—The exposure is very open, being in the Public Park, but the railed-off enclosure, which is only ten feet square, is too small. On comparing the thermometers it was found that the minimum had 0°·4 of spirit at the top of the tube.—*Observer*, C. Roscoe,

NEWTON REIGNY, *August 21st.*—Every thing at this station was in a very satisfactory condition and beautifully clean.—*Observer*, T. G. BENN, F.R.Met.Soc.

OAKAMOOR, *August 31st.*—The observer was away from home at the time of my visit, but the observations were in charge of the railway booking-clerk. The instruments were not in a satisfactory condition, the thermometer screen urgently requiring painting, and the muslin and cotton on the wet bulb being very dirty and nearly dry.—*Observer*, G. WILLIAMS.

OLD STREET, LONDON, *September 24th.*—The wet-bulb thermometer was broken on February 1st, and was replaced by a new thermometer on February 3rd. Every thing was in good order.—*Observer*, REV. A. P. HOCKIN.

ROUNTON, *July 27th.*—The barometer had been moved to a better position since the last inspection. The thermometers were found to have altered their zeros. The thermometer screen required painting.—*Observer*, Sir I. L. BELL, F.R.S., F.R.Met.Soc.

SCALEBY, *August 25th.*—The instruments at this station were in good order. More attention should be paid to the changing of the muslin and cotton on the wet-bulb thermometer, as the readings from this instrument are not always satisfactory.—*Observer*, R. A. ALLISON, M.P., F.R.Met.Soc.

SCARBOROUGH, *July 28th.*—The instruments were all correct and the station in good order. The thermometer screen had recently been painted.—*Observer*, A. ROWNTREE, F.R.Met.Soc.

SEATHWAITE, *August 24th.*—This station was in good order.—*Observer*, W. DIXON.

SOMERLEYTON, *August 12th.*—This station was in a satisfactory condition, the instruments being all in good order.—*Observer*, REV. C. J. STEWARD, M.A., F.R.Met.Soc.

SOUTHEND, *September 30th.*—The thermometers were all correct. The mercury in the maximum thermometer jumped up 3° or 4° after being set when fixed in the screen. The observer agreed to procure another thermometer. As the water receptacle was at a considerable distance from the wet bulb, the observer was requested to have it placed in a different position. The thermometer screen required painting.—*Observer*, G. LINGWOOD.

ST. MICHAEL'S-ON-WYRE, *August 27th.*—All the instruments were correct and every thing in good order.—*Observer*, REV. P. J. HORNBY.

STAPLETON, *August 25th.*—The thermometers were all correct except the minimum, which had some spirit at the top of the tube. The tube of the maximum thermometer had slipped down a little, so that the divisions on the tube were 1° lower than on the porcelain scale. I readjusted the tube, so as to obviate any future liability to error. The rain-gauge required to be properly fixed and adjusted. [Dr. Stirling left Stapleton at the end of September, but it is hoped that Dr. Lorraine, his successor, will continue the observations.]—*Observer*, A. W. STIRLING, M.B.

STRELLEY, *September 2nd.*—This station was in good order.—*Observer*, T. L. K. EDGE, F.R.Met.Soc.

USHAW, *July 24th.*—This station is about four miles west-south-west of

Durham. The ground is hilly in the neighbourhood. The exposure is very open; the ground (600 feet above sea-level) rises to the north-west, the highest point being about thirty feet higher. The thermometer screen was much too low, the bulbs being only three feet above the ground; it was also very dirty, and had not been painted for five years. The observer undertook to have the screen raised to the proper height, and to have it thoroughly painted. The rain-gauge was in a courtyard with a high building on the north. It was arranged that the gauge should be moved to a more open situation near the thermometer screen on January 1st, 1886.—*Observer*, Rev. J. Corbishley, B.A.

Wakefield, *July 28th.*—The thermometer screen and instruments were very dirty, and the wet bulb was not working properly. The instruments were cleaned and the wet-bulb thermometer put in working order before the inspector left, and it was arranged that the screen should be painted.—*Observer*, H. Clarke, M.R.C.S., F.R.Met.Soc.

Watford, *September 19th.*—On comparing the thermometers it was found that the dry, wet, and maximum all read 0°·2 too high. The divisions on the tube of the minimum thermometer did not quite agree with those on the porcelain scale. The thermometer screen required painting.—*Observer*, J. Hopkinson, F.R.Met.Soc.

APPENDIX II.

Rules under which Papers are accepted by the Society.

1. Every Paper which may be presented to the Society shall be considered as the property of the Society, unless there shall have been any previous engagement by the Council with its author to the contrary; and the Council may publish the same in any way, and at any time, that they may think proper. But should the Council refuse or omit within a year to publish such Paper, the author shall have a right to copy the same and publish it under his own direction. No other person, however, shall publish any Paper belonging to the Society without the written consent of the Council signed by one of the Secretaries (By-Law 62).

2. No Author shall be allowed to have his Paper returned to him after it has been read and ordered to be printed until it is in type, unless there shall have been previous engagement by the Council with the author to the contrary.

3. Should the cost of the author's corrections of the press amount to a greater sum than One Shilling and Sixpence per page, the excess shall be borne by the author himself, and not by the Society.

4. It is desirable that Diagrams intended for inclusion in the text should not exceed four inches in the smallest, and seven inches in the largest dimension, and that they be drawn with extreme neatness.

5. In the case of charts of the British Isles or of the North Atlantic, it is

requested that the outline Maps prepared by the Society be used, copies of which can be had on application.

6. Authors of Papers printed in the *Quarterly Journal*, in addition to forty separate copies presented free of expense, may, on payment of the cost of such extra copies, have any further number not exceeding one hundred, except by special order of the Council.

7. If proofs of papers be sent to the authors for correction, and be retained by them beyond seven days for each sheet of such proof, it will be assumed that such proof requires no further correction.

8. The time allowed for the reading of a Paper at the Meetings of the Society is limited to twenty minutes.

APPENDIX III.

Petition against the "Corporate Property Security Bill."

To the Honourable the Commons of the United Kingdom of Great Britain and Ireland in Parliament assembled.

The Humble Petition of the Council of the Royal Meteorological Society

Sheweth—

1. That your Petitioners have had under consideration a Bill now before your Honourable House, intituled "A Bill for better securing their property to Corporate and Quasi-corporate Associations."

2. That the said Society was founded in the year 1850, was incorporated by Royal Charter in the year 1866, and received Royal permission in the year 1883 to be called the "Royal Meteorological Society." That the Society has, under the same Charter, full power to dispose of the Corpus and Income of all property, real or personal, belonging to it, subject to certain restrictions more particularly set forth in such Charter.

3. That the provisions of the Bill would unduly restrict the power and independence of the said Society in the management of its own property, and the disposal of it to the best advantage, and would unreasonably and unnecessarily augment the difficulty and expense of such management.

4. That the said Bill is calculated to encourage State interference with the private concerns of associated enterprises, and to prevent or discourage the formation and endowment of associations similar to the said Society, for professional, scientific, and social purposes, beneficial and useful in themselves, and of indirect advantage to the public at large.

5. Your Petitioners humbly submit that the Bill is without precedent, and unnecessary, and calculated to cause mischief, difficulties, and, in some cases, injustice; and they humbly pray that the Bill may not be allowed to pass into law, or that it may be so amended by reference to a Select Committee, or otherwise, that it may not injuriously affect such Chartered Societies as the Royal Meteorological Society.

And your Petitioners will ever pray, &c.

Sealed with the Seal of the Society, in the presence of the Council, this 17th day of April, One Thousand Eight Hundred and Eighty-Five.

L.S.

ROBERT H. SCOTT, President.
G. M. WHIPPLE, Secretary.

APPENDIX IV.

Obituary Notices.

The Rev. Francis Redford, M.A., who was educated in the first instance for the medical profession, was ordained in 1848, and was for some time a missionary in Trinidad. On returning to this country he was instituted to the living of St. Paul's, Silloth, which he held till the time of his death. He led an unobtrusive life, and outside his parish was only known in connection with his meteorological observations and his Secretaryship to the Cumberland and Westmoreland Convalescent Institution.

He watched with much interest the rise and progress of the new port of Silloth, and his meteorological observations proved of great service in bringing it into public favour as a health resort. He supplied his observations to the *Carlisle Journal* regularly for about thirty years, without once missing a post or a train. In fact he was most methodical and punctual in all his arrangements. Failing health compelled him to give up work in the early part of the year, and his meteorological observations were discontinued at the end of June. He died on September 30th, in the seventy-second year of his age. He was also a Fellow of the Royal Society of Edinburgh.

Cornelius Walford was born in 1827, and was the eldest son of the late Mr. Cornelius Walford, of Witham, near Chelmsford. He was brought up to the legal profession, and served his articles in the office of Messrs. Pattisson, of Witham, where he was extensively engaged in the management of landed property. Whilst still a youth he organised a Building Society, which became the model and parent of other similar associations in the Eastern Counties. He also acted as a local insurance agent, and his experience in this business led to his becoming the inspector and organiser of several insurance companies in London. He was called to the bar as a member of the Middle Temple in 1860, and before long he came to be largely consulted as a legal adviser and an arbitrator in some of the most intricate and delicate cases arising out of the subject of insurance. He also took an active part in the direction of the Accident Insurance Company, and of many commercial companies.

In 1871 he commenced his great work the *Insurance Cyclopædia*, which is still incomplete although it extends to several volumes. He was also the author of several other works and many statistical papers. Mr. Walford, after an illness of many months' duration, died on September 28th.

He was a Fellow of the Statistical and several other Societies.

APPEN-

ABSTRACT OF RECEIPTS AND EXPENDITURE

RECEIPTS.

	£ s. d.	£ s. d.
Balance from 1884		196 9 9
Dividends—M. S. and L. R. 4½ Debenture Stock, £800	34 19 9	
Do. N. S. W. Stock, 4 per Cent., £500	19 7 6	
Do. New 3 per Cents., £200	5 16 3	
		60 3 6
Subscriptions for 1881	2 1 0	
Do. 1882	2 1 0	
Do. 1883	3 0 0	
Do. 1884	24 0 0	
Do. 1885	636 9 0	
Do. 1886	27 0 0	
Entrance Fees	21 1 0	
		715 12 0
Meteorological Office:—		
Copies of Weekly Returns	4 17 0	
Do. Monthly "	100 0 0	
Do. Annual "	2 10 0	
Grant towards Inspection Expenses	25 0 0	
		132 7 0
Sale of Publications		25 8 11
Excess for Author's Corrections		0 13 0
		£1130 14 2

DIX V.

FOR THE YEAR ENDING DECEMBER 31ST, 1885.

EXPENDITURE.

	£ s. d.	£ s. d.
Journal, &c.:—		
Printing Nos. 53-56	187 3 6	
Illustrations	32 13 5	
Authors' Copies	15 5 6	
Meteorological Record, Nos. 15-18	55 2 9	
Registrar-General's Report	8 8 0	
		298 13 2
Printing, &c.:—		
General Printing	19 8 6	
List of Fellows	10 13 0	
Forms for Observations	17 2 6	
Stationery	14 8 10	
Books, Bookbinding and Map	36 1 6	
		97 14 4
Salaries:—		
Assistant-Secretary	175 0 0	
Computers	153 8 0	
		328 8 0
Office Expenses:—		
Rent and Housekeeper	49 0 0	
Furniture and Repairs	11 4 11	
Coals, Insurance, &c.	3 17 6	
Postage	44 8 10	
Parcels and Petty Expenses	7 13 4	
Refreshments at Meetings	13 6 1	
International Inventions Exhibition Expenses	25 3 0	
Subscription overpaid returned	1 1 0	
Solicitor's Expenses, Cheque Book, &c.	2 3 4	
		157 18 0
Observations:—		
Inspection of Stations and Photography	52 3 11	
Observers at Old Street and Seathwaite	7 2 0	
Instruments	1 12 6	
		60 18 5
Stock:—		
Purchase of £31 13s. 4d. New 3 per Cents.		31 15 0
		975 6 11
Balance:—		
At Bank of England	134 14 1	
In hands of the Assistant-Secretary	20 13 2	
		155 7 3
		£1130 14 2

Examined and compared with the vouchers and found correct,

J. S. HARDING,
H. SOWERBY WALLIS, } *Auditors.*

11th January, 1886.

APPENDIX V.—*Continued.*

Abstract of Assets and Liabilities on January 1st, 1886.

Liabilities.

	£	s.	d.
To Subscriptions for 1886, paid in advance	27	0	0
,, Excess[1] of Assets over Liabilities	2053	9	11
	£2080	9	11

Assets.

	£	s.	d.	£	s.	d.
By Investments in M. S. and L. R. 4½ Debenture Stock, £800 at 127	1016	0	0			
,, Investments in N. S. W. Stock 4 per Cent. £500 at 105¼	526	5	0			
,, ,, New 3 per Cents. £200 at 100	200	0	0			
				1742	5	0
,, Subscriptions unpaid, estimated at	40	0	0			
,, Entrance Fee unpaid	1	0	0			
,, Dividend—M. S. and L. R. 4½ Debenture Stock, £800	17	8	0			
,, ,, N. S. W. Stock, 4 per cent., £500	9	13	4			
,, Meteorological Office—Weekly Returns, 1885	4	16	4			
				72	17	8
,, Furniture, Fittings, &c.	30	0	0			
,, Instruments	80	0	0			
				110	0	0
,, Cash in hands of Bank of England	134	14	1			
,, Do. the Assistant-Secretary	20	13	2			
				155	7	3
				£2080	9	11

J. S. HARDING, H. SOWERBY WALLIS, } *Auditors.*

WILLIAM MARRIOTT, *Assistant-Secretary.*

11th January, 1886.

[1] This excess is exclusive of the value of the Library and Stock of Publications.

APPENDIX VI.

List of Books Purchased.

Addison, W.—Meteorological Journal, 1833 to 1838; containing Observations made at Great Malvern, Worcestershire. (MS.)

A General Chronological History of the Air, Weather, Seasons, Meteors, &c. Two vols. 8vo. (1749.)

British Association.—Reports, 1838 to 1840. 8vo. (1839-41.)

Cornelius, C. S.—Meteorologie. 8vo. (1863.)

Denison, Dr. C.—Seasonal Climatic Map of the United States. Wall map. (1885.)

Encyclopædia Britannica. Ninth Edition. Vols. XVIII. and XIX. 4to. (1885.)

Glaisher, J., F.R.S.—Travels in the Air. 8vo. (1871.)

Hicks, J. J.—Specification of Improvements in Clinical Thermometers. 4to. (1884.)

International Inventions Exhibition, 1885.—Official Catalogue. Third Edition. 8vo. (1885.)

Kamtz, Dr. L. F.—Vorlesungen über Meteorologie. 8vo. (1840.)

L'Institut Meteorologique Danois et le Deutsche Seewarte.—Cartes Synoptiques Journalières du Temps, embrassant le Nord de l'Atlantique, June 1881 to Feb. 1882. Folio. (1884.)

Meteorological Office.—Return of Storms for which no Warning was issued which have visited the British Islands between Jan. 1, 1874, and Dec. 31, 1883. Foolscap Folio. (1884.)

Murphy, P.—The Anatomy of the Seasons. 8vo. (1834.)

Pearce, A. J.—The Weather Guide-Book. 8vo. (1864.)

Prestel, Dr. M. A. F.—Der Sturmwarner und Wetteranzeiger. 8vo. (1870.)

St. Alban, Viscount.—The Naturall and Experimentall History of Winds, &c. 12mo. (1653.)

Scott, R. H., F.R.S.—The Upper Air. 8vo. (1885.)

Steinmetz, A.—Sunshine and Showers. 8vo. (1867.)

The "Times" Register of Events in 1884. 8vo. (1885.)

Whistlecraft, O.—The Weather Almanac, 1859 to 1869. 8vo. (1858-68.)

Year Book of the Scientific and Learned Societies of Great Britain and Ireland, 1885. 8vo. (1885.)

APPENDIX VII.

Donations received during the Year 1885.

Presented by Societies, Institutions, &c.

Adelaide, Observatory.—Meteorological Observations made in South Australia and the Northern Territory during 1882.

Adelaide, Royal Society of South Australia.—Transactions and Proceedings and Report, Vol. VII. 1883-84.

Batavia, Observatory.—Magnetical and Meteorological Observations, Vol. VI. 1881-82.—Rainfall in the East Indian Archipelago, 1884.

Berlin, Deutsche Meteorologische Gesellschaft.—Berliner Zweigverein, 1885.—Meteorologische Zeitschrift, Nov. 1884 to Nov. 1885.

Berlin, Kön. Statistischen Bureau.—Preussische Statistik, LXXXII. Ergebnisse der meteorologischen Beobachtungen im Jahre 1884.

Bombay, Government Observatory.—Magnetical and Meteorological Observations, 1883.

Brisbane, General Register Office.—Report of Registrar-General on Vital Statistics, 1884.—Report on the Vital Statistics, Oct. 1884 to Sept. 1885.

Brisbane, Royal Society of Queensland.—Proceedings, Vol. I. parts 2 to 4, 1884.

Bruxelles, Académie Royale.—Annuaire, 1884 and 1885. Bulletin, 3me Serie, Tomes 6 to 8, 1883-4.

BRUSSELS, OBSERVATOIRE ROYAL.—Annuaire, 1885—Bulletin Météorologique, Dec. 1884 to Nov. 1885.

BUKHAREST, INSTITUTUL METEOROLOGIC AL ROMANIEI.—Buletinul Ministerului Agriculturei, Industrici, Comerciului si Domeniilor. Annul I. 1885. Nos. 1 to 7.

CAIRO, MINISTERE DE L'INSTRUCTION PUBLIQUE.—Résumé Mensuel des Observations météorologiques faites à l'Observatoire Khédivial du Caire (Abbassieh), Jan. 1884 to Sept. 1885.

CAIRO, SOCIÉTÉ KHÉDIVIALE DE GÉOGRAPHIE.—Bulletin, IIe. Serie, Nos. 6 and 7.

CALCUTTA, METEOROLOGICAL OFFICE.—Indian Meteorological Memoirs, Vol. II. Parts 3 and 4.—Registers of Original Observations reduced and corrected, May 1884 to May 1885.—Report on the Administration of the Meteorological Department of the Government of India in 1883-84.—Report on the Meteorology of India in 1882 and 1883.

CALCUTTA, ST. XAVIER'S COLLEGE OBSERVATORY.—Meteorological Observations, July 1884 to June 1885.

CAPE TOWN, METEOROLOGICAL COMMISSION.—Report for the year 1884.

CAPE TOWN, SOUTH AFRICAN PHILOSOPHICAL SOCIETY.—Transactions, Vol. III. 1881-3.

CHEMNITZ, KÖNIGL. SÄCHS. METEOROLOGISCHEN INSTITUTES.—Dekadenbericht im Jahre 1884.—Jahrbuch, 1884.

CHRISTIANIA, EDITING COMMITTEE, NORWEGIAN NORTH ATLANTIC EXPEDITION, 1876-1878.—Zoology, Crustacea, Ia. and Ib., by G. O. Sars.—Pennatulida, by D. C. Danielssen and J. Koren.—Spongiadæ, by Dr. G. A. Hansen.

CHRISTIANIA, NORWEGISCH METEOROLOGISCHES INSTITUT.—Jahrbuch für 1884.

COPENHAGEN, DANSKE METEOROLOGISKE INSTITUT.—Bulletin Météorologique du Nord, Dec. 1884 to Nov. 1885.—Meteorologisk Aarbog, 1882, Parts 1 to 3, and 1883, Parts 1 to 3.

CORDOBA, ACADEMIA NACIONAL DE CIENCIAS —Actas, Tomo V. parts 1 and 2.—Boletin, Tomo VI. part 4, to Tomo VII. part 3.

CORDOBA, OFICINA METEOROLÓGICA ARGENTINA.—Anales, Tomo IV.—Informes Anuales y Documentos, 1885.

CRACOW, K. K. STERNWARTE.—Meteorologische Beobachtungen, Dec. 1884 to Oct. 1885.

DORPAT, METEOROLOGISCHE OBSERVATORIUMS.—Anemometrische Scalen für Dorpat. Ein Beitrag zur Klimatologie Dorpats, von Prof. K. Weihrauch.

DUBLIN, GENERAL REGISTER OFFICE.—Supplement to the Seventeenth Report of the Registrar-General of Births, Marriages and Deaths in Ireland, containing decennial summaries for the years 1871-1880.—Twenty-first detailed Annual Report of the Registrar-General of Births, Marriages and Deaths in Ireland, 1884.—Weekly Returns of Births and Deaths, Vol. XXI. No. 52, to Vol. XXII. No. 51.

DUBLIN, ROYAL DUBLIN SOCIETY.—Scientific Proceedings, Vol. IV. (N.S.) Parts 5 and 6.—Scientific Transactions, Vol. III. (Series II.) Parts 4 to 6.

DUBLIN, ROYAL IRISH ACADEMY.—Proceedings; Science, Ser. II. Vol. IV. Nos. 3 and 4; Polite Literature and Antiquities, Ser. II. Vol. II. No. 6.—Todd Lecture Series, Vol. II. part 1; Irish Lexicography. By Prof. R. Atkinson.—Transactions; Science, Vol. XXVIII. Nos. 17 to 20.

DULWICH COLLEGE SCIENCE SOCIETY.—Seventh Annual Report, 1884-5.

EDINBURGH, GENERAL REGISTER OFFICE.—Quarterly Returns of the Births, Deaths and Marriages registered in Scotland for the quarters ending December 31st, 1884, and June 30th and Sept. 30th, 1885.

EDINBURGH, SCOTTISH METEOROLOGICAL SOCIETY.—Journal, Third Series, No. 2.

FALMOUTH, ROYAL CORNWALL POLYTECHNIC SOCIETY.—Annual Reports, 1870 to 1873, 1875 to 1879, and 1881.

FIUME, I. R. ACCADEMIA DI MARINA.—Meteorological Observations, Nov. 1884 to Oct. 1885.

GENEVA, OBSERVATOIRE.—Résumé Météorologique de l'Année 1884 pour Genève et le Grand Saint-Bernard, Par E. Gautier et A. Kammermann.

GENEVA, SOCIÉTÉ DE GÉOGRAPHIE.—Le Globe. Bulletin, Tomo IV., Nos. 1 and 2.

GLASGOW, PHILOSOPHICAL SOCIETY.—Proceedings, Vols. XV. and XVI.

GREENWICH, ROYAL OBSERVATORY.—Magnetical and Meteorological Observations, 1883.—Report of the Astronomer Royal to the Board of Visitors, June 6, 1885.

HALLE, KAISERLICHE LEOPOLDINO-CAROLINISCHE DEUTSCHE AKADEMIE DER NATURFORSCHER.—Beitrag zur Frage der Reduction von Barometerständen auf ein anderes Niveau. Von Dr. P. Schreiber.—Bestimmung der Masse des Planeten Jupiter aus Heliometer.—Beobachtungen der Abstände seiner Satelliten. Von Dr. W. Schur.—Leopoldina, XX. 1884.

HAMBURG, DEUTSCHE SEEWARTE.—Aus dem Archiv, 1882 and 1883.—Meteorologische Beobachtungen in Deutschland, 1882.—Monatliche Uebersicht der Witterung, March 1884 to Feb. 1885.—Wetterbericht, 1885.

HAMILTON ASSOCIATION.—Journal and Proceedings, 1882-83. Vol. I. part 1.

HONGKONG, OBSERVATORY.—Annual Report of the Government Astronomer for 1884,—

Annual Weather Report for 1884.—Five-Day Means of the Principal Meteorological Elements for 1884.—Lunar Transits across the Meridian of Hongkong.—Observations and Researches made at the Hongkong Observatory in the year 1884. By W. Doberck. —On the Height of Victoria Peak.—On the Progressive Motion of Typhoons in 1884.—Weather Report, July 1884 to April 1885.

IOWA, WEATHER SERVICE.—First to Third Biennial Reports of the Central Station.—Reports, 1878, 1879, 1881 and 1882.

KEW OBSERVATORY.—Report of the Kew Committee for the year ending October 31, 1884.—The History of the Kew Observatory. By Robert H. Scott, F.R.S.

LEON, OBSERVATORIO DEL COLEGIO.—Resumen General de las Observaciones Meteorologicas, 1884.

LISBON, OBSERVATORIO DO INFANTE D. LUIZ.—Annaes. Observaçoes dos Postos Meteorologicos, 1881 and 1882.—Annaes. Vigesimo Octavo Anno. 1882, Volume XX.

LISBON, SOCIEDADE DE GEOGRAPHIA.—Boletim, 4a Serie, Nos. 10 to 12.—5a Serie, Nos. 1 to 5.—Resposta á Sociedade Anti-Esclavista de Londres, por J. A. C. Real.—Subsidios para a Historia do jornalismo nas Provincias Ultramarinas Portuguezas pelo socio Brito Aranha.

LIVERPOOL, LITERARY AND PHILOSOPHICAL SOCIETY.—Proceedings, Vol. XXXVIII. 1883-4.

LONDON, BRITISH ASSOCIATION.—Report, 1884.

LONDON, COLONIAL OFFICE.—First Annual Report of the Government Astronomer, Hongkong Observatory, for 1884.—Observations and Researches made at the Hongkong Observatory in the year 1884. By W. Doberck.

LONDON, GENERAL REGISTER OFFICE.—Annual Summary of Births, Deaths, and Causes of Death in London, and other great towns, 1884.—Quarterly Returns of Marriages, Births, and Deaths, for the four quarters ending Sept. 30, 1885.—Weekly Returns of Births and Deaths, Vol. XLV. No. 52 to Vol. XLVI. No. 51.

LONDON, GEOLOGICAL SOCIETY.—Quarterly Journal, Nos. 161 to 164.

LONDON, INSTITUTION OF CIVIL ENGINEERS.—Physiography. By Dr. J. Evans, F.R.S.

LONDON, INSTITUTION OF MECHANICAL ENGINEERS.—Proceedings, 1885, No. 2.

LONDON, INTERNATIONAL HEALTH EXHIBITION.—Health Exhibition Literature, Vols. XVII. to XIX.

LONDON, METEOROLOGICAL OFFICE.—Abstract of the Weather at Penzance for the year 1883. By W. H. Richards.—Annual Report of the Royal Cornwall Polytechnic Society, 1884.—Bulletin quotidien de l'Algérie, Nov. 16, 1884, to Jan. 15, Feb. 16 to May 15, and June 16 to Nov. 30, 1885.—Contributions to our knowledge of the Meteorology of the Arctic Regions, Part IV.—Daily Weather Reports, 1885.—Ergebnisse der an den meteorologischen Stationen des Grossherzogthums Baden, 1882-83.—Hourly Readings, Oct. 1882 to June 1883.—Magnetic Observations taken at Kazan during the year 1883.—Mauritius Meteorological Results, 1881 and 1883.—Meteorological Observations at Stations of the Second Order for the year 1880.—Meteorological Observations made at Southport, August 23, 1884, to Dec. 4, 1885.—Meteorology of Ceylon for 1884.—Monthly Weather Report, Oct. 1884 to July 1885.—New York State Library, 65th Annual Report, 1882.—Observaciones Meteorologicas hechas en el Observatorio Astronomico de Santiago, 1873 to 1881.—On the Impurities in London Air. By Dr. W. J. Russell, F.R.S.—Osservazioni Meteorologiche fatte in Alessandria alla Specola del Seminario, 1879 to 1882.—Papers and Proceedings of the Royal Society of Tasmania for 1884.—Principles of Forecasting by means of Weather Charts. By the Hon. R. Abercromby.—Quarterly Weather Report, 1877. Parts 1 to 3.—Report of the Meteorological Council to the Royal Society for the year ending 31st March, 1884.—Report on Wind Velocities at the Lake Crib and at Chicago.—Researches on Solar Heat and its absorption by the Earth's Atmosphere. A Report of the Mount Whitney Expedition. By S. P. Langley.—Service Central Météorologique de l'Algérie. Bulletin Mensuel, Nos. 1 and 2.—Temperature Chart of the United States. Constructed by C. A. Schott.—Temperature of the Atmosphere and Earth's Surface. By Prof. W. Ferrel.—The Elements of the Heliograph.—The relation between Northers and Magnetic Disturbances at Havana, Cuba. By Sergt. G. E. Curtis.—The special characteristics of Tornadoes, with practical directions for the protection of life and property.—The study of Meteorology in the higher schools of Germany, Switzerland, and Austria.—Variation of Rainfall west of the Mississippi River.—Weekly Weather Report. New Series, Vol. I. No. 51 to Vol. II. No. 51.—Western Australia. Meteorological Report for the year 1883.

LONDON, ROYAL AGRICULTURAL SOCIETY.—Journal, Second Series, Vol. XXI.—General Index to the Second Series of the Journal, Vols. XI. to XX.

LONDON, ROYAL ASTRONOMICAL SOCIETY.—Memoirs, Vol. XLVIII. Part 2.—Monthly Notices, Vol. XLV. No. 2 to Vol. XLVI. No. 1.

LONDON, ROYAL BOTANIC SOCIETY.—Quarterly Record, Nos. 20 to 23.

LONDON, ROYAL INSTITUTION OF GREAT BRITAIN.—Proceedings, No. 78.

LONDON, ROYAL SOCIETY.—Proceedings, Nos. 234 to 239.

LONDON, ROYAL UNITED SERVICE INSTITUTION.—Journal, No. 129.

London, Society of Arts.—Journal, Nos. 1676 to 1727.

London, Society of Telegraph Engineers & Electricians.—Journal, Nos. 54 to 58.

London, Westminster Free Public Library.—Twenty-eighth Annual Report, 1884-85.

Lyon, Observatoire.—Annales, Première Série, Météorologie. Tome I. Fascicule II. 1878-79-80.—Note sur les Oscillations Barométriques produites par l'éruption du Krakatoa. Par C. André.

Madras, Government Observatory.—Magnetical Observations made at the Hon. East India Company's Observatory at Madras, 1851-55.—Magnetical Observations made at the Hon. East India Company's Observatory at Singapore, 1841-45.—Telegraphic Determinations of the difference of longitude between Karachi, Avanashi, Roorkee, Pondicherry, Colombo, Jaffna, Muddapur and Singapore, and the Government Observatory, Madras.

Madrid, Observatorio.—Anuario, Año XVIII. 1880.—Observaciones Meteorológicas, 1879 to 1881.—Resúmen de las Observaciones Meteorológicas de Provincias, 1876 to 1880, and 1882.

Madrid, Sociedad Geografica.—Boletin, Tomo XVII. No. 4 to Tomo XIX. No. 4.

Magdeburg, Wetterwarte der Magdeburgischen Zeitungs.—Das Wetter, April, May, July, August, and Oct. 1884 to Dec. 1885.

Manchester, Literary and Philosophical Society.—Memoirs, Third Series, Vol. VIII.—Proceedings, Vols. XXIII. and XXIV.

Marlborough College Natural History Society.—Report for 1884.—Results of Twenty Years' Observations on Botany, Entomology, Ornithology and Meteorology, taken at Marlborough College, 1865-1884.

Mauritius, Royal Alfred Observatory.—Annual Report of the Director, 1883.—The Mortality from Malarial Fever compared with the Rainfall, Temperature and Relative Humidity for the period 1871 to 1883, and for the year 1883.

Melbourne, Observatory.—Monthly Records of Results of Observations in Meteorology, Terrestrial Magnetism, etc. Sept. 1884 to June 1885.

Melbourne, Patent Office.—Indexes of Patents and Patentees for the years 1878 and 1879.

Melbourne, Royal Society of Victoria.—Transactions and Proceedings, Vol. XXI.

Metz, Académie.—Observations Météorologiques faites à Metz pendant l'année 1880, par M. Schuster.

Mexico, Ministerio de Fomento.—Boletin, Tomo IX. No. 65 to Tomo X. No. 36, and Tomo X. Nos. 43-97.

Mexico, Observatorio Astronómico Nacional de Tacubaya.—Anuario para el año de 1886.

Michigan, State Board of Health.—Co-operation of Citizens in preventing the Spread of Disease, by Rev. W. Masker.—Meteorological Report from Observations made at the State Capitol, Lansing, Dec. 14, 1884, to Dec. 12, 1885.—Michigan Crop Report, Dec. 1884 to Nov. 1885.—Proceedings and Addresses at Sanitary Conventions held at Hillsdale, East Saginaw, and Lansing.—The Public Health Service of Michigan, by Hon. Dr. J. Avery.

Milan, R. Osservatorio di Brera.—Osservazioni Meteorologiche eseguite nell' anno 1884.—Sui Temporali Osservati nell' Italia Superiore durante l' anno 1879. Relazione di E. Pini.—Teoria degli Stromenti Ottici con applicazioni ai Telescopi ed alla Fotografia Celeste. Del Dr. L. Billotti.

Moncalieri, Osservatorio R. C. Carlo Alberto.—Observatorio Meteorológico Central del Colegio Pio de Villa Colon (Montevideo). Resumen de las observaciones meteorológicas practicadas en el año 1883-84.

Montreal, Geological Survey of Canada.—Report of Progress, 1882-83-84.

Moscow, Landwirthschaftliche Akademie.—Meteorologische Beobachtungen ausgeführt am meteorologischen Observatorium, 1884.

Munich, K. B. Meteorologische Central Station.—Beobachtungen der meteorologischen Stationen im Kon. Bayern, Heft 3, 1884, to Heft 2, 1885.—Uebersicht über die Witterungsverhältnisse im Kon. Bayern, Nov. 1884 to Nov. 1885.

Munich, K. Sternwarte.—Meteorologische und magnetische Beobachtungen. 1884.

Natal, Observatory.—Report of the Superintendent for 1884.

Newhaven, Connecticut Academy of Arts and Sciences.—Transactions, Vol. VI. Part 2.

New York, Central Park Observatory.—Abstracts of Registers from Self-Recording Instruments, Dec. 1884 to Nov. 1885.

Oxford, Radcliffe Observatory.—Results of Meteorological Observations, 1882.

Paris, Academy of Sciences.—Mission Scientifique du Cap Horn. 1882-1883. Tome II. Météorologie. Par Lieut. J. Lephay.

Paris, Bureau Central Météorologique de France.—Annales; 1881, part 2; 1882, parts 1, 3 and 4.—Bulletin International, 1885.—Instructions Météorologiques. Deuxième Edition, Rapport du Comité Météorologique International, Réunion de Copenhague, 1882.

PARIS, INTERNATIONAL METEOROLOGICAL COMMITTEE.—Rapport sur l'employment des observations des cirrus pour les prévisions journalières du temps, par Capt. J. C. de Brito Capello, Dr. H. H. Hildebrandsson, et Rev. W. C. Ley.

PARIS, SOCIÉTÉ MÉTÉOROLOGIQUE DE FRANCE.—Annuaire, Dec. 1882, and May 1884 to Feb. 1885.

PHILADELPHIA, AMERICAN PHILOSOPHICAL SOCIETY.—Proceedings, Nos. 116 to 120.—Register of Papers published in the Transactions and Proceedings.

POLA, K. K. HYDROGRAPHISCHES AMT.—Meteorologische und magnetische Beobachtungen, Jan. to Nov. 1885.

PRAGUE, K. K. STERNWARTE.—Magnetische und meteorologische Beobachtungen im Jahre 1884.

PROVIDENCE, R. I., NEW ENGLAND METEOROLOGICAL SOCIETY.—Bulletin, Nos. 1 to 13.

ST. PETERSBURG, PHYSIKALISCHES CENTRAL OBSERVATORIUM.—Annalen, 1883.

SAN FERNANDO, INSTITUTO Y OBSERVATORIO DI MARINA.—Anales. Seccion 2a. Observaciones Meteorológicas, 1883 and 1884.

STOCKHOLM, K. SVENSKA VETENSKAPS AKADEMIE.—Observations Météorologiques Suédoises, 1878 and 1879.

STONYHURST COLLEGE OBSERVATORY.—Results of Meteorological and Magnetical Observations, 1884.

SYDNEY, GOVERNMENT OBSERVATORY.—Results of Rain and River Observations made in New South Wales during 1884.

SYDNEY, ROYAL SOCIETY OF NEW SOUTH WALES.—Journal and Proceedings. Vol. XVIII. 1884.

TIFLIS, PHYSIKALISCHEN OBSERVATORIUM.—Beobachtungen der Temperatur des Erdbodens, 1881 to 1883.—Magnetische Beobachtungen, 1883.—Meteorologische Beobachtungen, 1883 and 1884.

TOKIO, IMPERIAL METEOROLOGICAL OBSERVATORY.—Monthly Summaries and Monthly Means for the year 1884.

TOKIO, UNIVERSITY.—Measurement of the Force of Gravity and Magnetic Constants at Ogasawarajima (Bonin Island). Reported by A. Tanakadate.—Measurement of the Force of Gravity at Naha (Okinawa) and Kagoshima. By S. Sakai and E. Yamaguchi.

TORINO, OSSERVATORIO ASTRONOMICO DELL' UNIVERSITÀ.—Effemeridi del Sole, della Luna e dei principali Pianeti calcolate per Torino per l' anno 1886. Dall Prof. A. Charrier.—Osservazioni dell' Ecclisse Totale di Luna del 4-5 Ottobre 1884. Nota di A. Dorna.

TORINO, SOCIETÀ METEOROLOGICA ITALIANA.—Bollettino Decadico, pubblicato per cura dell' Osservatorio Centrale del Real Collegio Carlo Alberto in Moncalieri, Feb. 1884 to March 1885.—Bollettino Mensuale, Serie II. Vol. IV. No. 4 to Vol. V. No. 8.—Istruzioni per le osservazioni della Luce Zodiacale in Italia. Del P. A. Serpieri.—Istruzioni per le osservazioni delle Correnti Terrestri. Del Prof. I. Galli.—Istruzioni per le osservazioni Meteorologiche e per l' Altimetria Barometrica, del P. F. Denza.—Istruzioni per le osservazioni sul Mare e sulle Brezze. Del Prof. G. Roberto.—L' Astronomia la Fisica Terrestre e la Meteorologia alla. Esposizione Generale Italiana in Torino 1884.—Materiali per l' Altimetria Italiana, Fascicolos 1 and 2.—Studi sui Barometri Normali dell' Osservatorio Centrale di Moncalieri. Nota seconda. Del P. F. Denza.

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TORONTO, METEOROLOGICAL OFFICE.—Monthly Weather Review, Nov. 1884 to Nov. 1885.

UPSALA, OBSERVATOIRE DE L'UNIVERSITÉ.—Bulletin Météorologique Mensuel, 1884.

UTRECHT, K. NEDERLANDSCH METEOROLOGISCH INSTITUUT.—Nederlandsch Meteorologisch Jaarboek voor 1884.

VIENNA, K. K. CENTRALANSTALT FÜR METEOROLOGIE UND ERDMAGNETISMUS.—Beobachtungen, Nov. 1884 to Oct. 1885.—Jahrbuch, 1883.

VIENNA, OESTERREICHISCHE GESELLSCHAFT FÜR METEOROLOGIE.—Zeitschrift, 1885.

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WASHINGTON, WAR DEPARTMENT.—Monthly Weather Review, Nov. 1884 to Sept. 1885.

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Baker, Dr. H. B.—Typhoid Fever and low water in wells.

Ballou, Dr. N. E.—A condensed Statement of Meteorological Observations made at Sandwich, Illinois, 1852-84.

Binyon, J. B.—Rainfall, &c. at Blackrock, near Cork, Dec. 1884 to Nov. 1885. (MS.)

Blake, C. C.—The Future; a calculation of coming weather through astronomical mathematics. Vol. I. Nos. 1 and 2.

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Doberck, Dr. W.—Markree Observatory.

Doering, Dr. O.—Algunas Observaciones Meteorológicas practicadas en el año 1882 en Córdoba (República Argentina).—La Presion Atmosférica de Córdoba de Media en Media Hora.—Medicion Barométrica de algunas alturas de la Sierra de Córdoba.—Observaciones Meteorológicas hechas en Mil Nogales (Córdoba).—Observations Météorologiques faites à Córdoba pendant l'année 1883.—Sobre la conveniencia de fundar en la República Argentina un Observatorio Magnético con asiento en la Ciudad de Córdoba.

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Doyle, P.—Paper-making in India.

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Eassie, W.—Reports of the Commissioners appointed to inquire into the nature and extent of the several Bogs in Ireland, and the practicability of draining and cultivating them. (1812-14.)

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Hankinson, R. C.—Weather at Red Lodge, Southampton, Dec. 1884 to May 1885. (MS.)

Hann, Dr. J.—Bericht über die Fortschritte der geographischen Meteorologie.—Die Temperaturverhältnisse der österreichischen Alpenländer.

Harvey, Rev. C. W.—Meteorological Observations taken at Throcking, Herts, during the year 1883.—Rainfall in Herts. Jan. to Aug. 1885.—Report on the Rainfall in Hertfordshire in 1883.

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Jackson, W. E.—Meteorological Observations taken at Erenkeny, Constantinople, June 1 to Dec. 20, 1885. (MS.)

Kiessling, Prof. J.—Beobachtungen des rothen Sonnenringes.—Die Dämmerungserscheinungen im Jahre 1883 und ihre physikalische Erklärung.—Zur Erklärung der ringförmigen Gegen-Dämmerung.

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Lee, G. J.—Meteorological Observations taken at Kimberley, South Africa, Dec. 1, 1884 to Nov. 30, 1885. (MS.)

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Low, S., Junr.—Sanitary Suggestions.

Luvini, Prof. J.—Sept Etudes sur, 1. L'état sphéroidal; 2. Les explosions des machines à vapeur; 3. Les trombes; 4. La grêle; 5. L'électricité atmosphérique; 6. La réfraction laterale; 7. L'adhésion entre les liquides et les solides.

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Mercer, R. M.—Meteorological Observations with some Agricultural Notes as made by observers at certain stations in Kent during the year 1884. (MS.)

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Preston, Rev. T. A.—Wiltshire Rainfall, Dec. 1884 to Nov. 1885.

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Ringwood, A.—The Law of Storms.

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Roth, H. L.—Climate of New South Wales, by H. C. Russell.—Die physikalischen Einwirkungen des Waldes auf Luft und Boden und seine klimatologische und hygienische Bedeutung, von Dr. E. Ebermayer.—Hints for Invalids and Travellers, with observations on the Climate of Luxor and Egypt, by T. E. Maclean.—Instructions for Meteorological Observations in the Colony of New South Wales, by H. C. Russell.—Minutes of Proceedings of Intercolonial Meteorological Conference held at Melbourne on April, 1881.—Mountain Barometer Tables, by W. Gravatt.—MS. Meteorological Register of Observations made at Mackay, Queensland, 1876 to 1880.—Quantity of Water consumed in Irrigation, by W. W. Culcheth.—Return of Rainfall in Ceylon during 1880.—The Mackay (Queensland) Sugar Crop as affected by the weather and want of labour.—Ueber Bedeutung und Vertretung der Land und Forstwirthschaftlichen Meteorologie, von Dr. J. R. Lorenz.—Also several other books.

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Schück, Capt. A.—Beitrag zur Kenntniss der Geschwindigkeitsmessung auf See.

Sharpe, D. R.—Essex Rainfall, Aug. 1882 to June 1885.

Skinner, Dr. D. S.—The Science of Change of Air.

Slade, F.—Meteorological Observations for 1884 taken at Beckford, Tewkesbury.

Smellie, T. D.—Ocean and Air Currents.

Smith, B. Woodd.—A Record of Weather kept at Richmond, Surrey, from 1713 to 1745, by George Smith. (MS.)

Smyth, C. Piazzi.—On Brewster's Line Y, in the infra Red of the Solar Spectrum.

Symons, G. J., F.R.S.—A description of the nature, construction, and use of the Torricellian, or Simple Barometer, by B. Martin.—British Rainfall, 1884.—Description of Instruments designed for extending and improving Meteorological Observations, by J. Leslie.—Des Mouvements de l'Atmosphère, par M. le Contre-Amiral Bourgois.—Dialogo dell Cose Meteorologiche, di D. V. Zuccolo.—Difficiles Nugæ: or Observations touching the Torricellian experiment, by Sr. M. Hales.—Essais sur la Construction et Comparaison des Thermométres. Traduit de l'Anglois, du Dr. Martine.—Historisch-Kritische Uebersicht über die Hageltheorien, von C. Waehner.—J. B. du Hamel. De Meteoris et Fossilibus.—Meteorological Registers kept at Bockleton, Tenbury, 1815 to 1858 (MS.).—Meteorological Registers kept at Dunmow, Essex, July 1851 to June 1868. (MS.).—Meteorological Registers kept at Pool Cottage, Hereford, 1821 to 1842. (MS.).—Meteorological Registers kept at Reading Atheneum, Aug. 1831 to Dec. 1841, 1847 to 1849 and 1853-4. (MS.)—Meteorological Registers kept at Somers Town, 1783 to 1786 and 1800 to 1842. (MS.).—Meteorological Registers kept at Stroud, Jan. 1775 to March 1813. (MS.).—Météorologie et Phénoménologie de l'Attique.—On the Atmospheric Tides and Meteorology of Dukhun, by Lieut.-Col. W. H. Sykes, F.R.S.—Symons's Monthly Meteorological Magazine, 1885.—The Atmospheric Recorder, by G. Dollond.—Théorie mathématique des Oscillations du Baromètre et recherche de la loi de la variation moyenne de la température avec la latitude, par E. Liais.—Traité Elémentaire de Météorologie, par M. C. Bailly de Merlieux.—Ueber die Ausdünstung, und ihre Wirkungen in der Atmosphäre, von M. Hube.—Also about ninety books and pamphlets; and fifteen MS. Meteorological Registers kept at various places in Great Britain.

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„ 'The Sanitary Engineer,' Vol. XI. No. 4 to Vol. XIII. No. 2.

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Thompson, B.—On Swallow-Holes and Dumb Wells.—The Water Supply of the Town (Northampton).

Tischner, A.—The fixed Idea of Astronomical Theory.

Todd, Prof. D. P.—Observations of the Transit of Venus, 1882, made at the Lick Observatory, Mount Hamilton, California.

Tripe, Dr. J. W.—On Small Pox Hospitals.—Report on the Sanitary Condition of the Hackney District for the year 1884.

Tripp, W. B.—The River Buffalo.

Tyrer, R.—The Meteorology of Cheltenham, 1884.

Walker, A. O.—Climatic Causes affecting the distribution of Lepidoptera in Great Britain.

Whitley, N.—Results of the Meteorological Observations made at the Royal Institution of Cornwall, Truro, 1840-81. By Dr. C. Barham.

Wise, Dr. A. T.—Alpine Winter in its medical aspects.

Woeikof, Dr. A.—Die Regenverhältnisse des malayischen Archipel.—Flüsse und Landseen als Produkte des Klima's.—Temperaturänderung mit der Höhe in Bergländern und in der freien Atmosphäre.

Wragge, C. L.—Meteorological Observations made at Torrens Observatory, South Australia, during July 1885. (MS.)

Wright, P.—Rainfall, Temperature, and Sunshine in Montgomeryshire, during ten years ending 1884.

APPENDIX VIII.

Reports of Observatories, &c.

The Meteorological Office.—Lieut.-Gen. R. Strachey, R.E., C.S.I., F.R.S., Chairman of Council; Robert H. Scott, M.A., F.R.S., Secretary; Captain H.

Toynbee, F.R.A.S., Marine Superintendent; Nav. Lieut. C. W. Baillie, F.R.A.S., Assistant Do.—The only change in the Council during the year has been caused by the resignation of Mr. de la Rue, who had been connected with the governing body of the Office since its reconstitution in 1867. Mr. de la Rue's place has been taken by Professor George Darwin.

Marine Meteorology.—The investigation into the Meteorology of the North Atlantic for the thirteen months August 1882 to August 1883 inclusive has made steady progress. Two charts have been drawn for each day, one showing the barometer and wind, the other the temperature of air and sea. The records of weather are inserted in both charts. The series for the first month, August 1882, has gone to press, and considerable advance has been made with those for the subsequent months.

The Council have decided to take up the Meteorology of the Red Sea, and charts have been prepared showing Winds, Currents, the Pressure and Temperature of the Air, the Readings of the Wet Bulb, and the Temperature and Specific Gravity of the Sea Surface for one month as a specimen. The results present many features of interest.

The Charts of Barometrical Pressure for all the oceans are in the engraver's hands. Like those of Sea Surface Temperature, they are only for the four months February, May, August and November.

The Council have decided on the preparation of Monthly Current Charts for all the oceans, a work which will occupy a long time, but which may be expected to be of high value to the Nautical World.

Part IV. of *Contributions to our knowledge of the Meteorology of the Arctic Regions* was published in 1885. It completes the series of expeditions sent out in search of Sir John Franklin's Expedition, except the vessels which passed into the Arctic Regions *viâ* Behring Strait. The meteorological results are for Princess Royal Islands, Mercy Bay, Dealy Island, Melville Sound, and Beechey Island. The observations made at these places have not before been fully discussed.

Weather Telegraphy.—Self-recording Aneroids have been supplied to five of the principal outlying stations, in order to aid the observers in reporting the changes which have taken place in pressure between the usual hours of observation.

Arrangements have been made with the Chief Signal Officer, U. S., for sending occasional telegrams to the Meteorological Office (1) as to storms which have been experienced by outward bound steamers, between long. 45° W and the United States; and (2) as to derelict ships and ice passed on any part of their voyage. The system was modified somewhat in September, and it is hoped may ultimately prove of considerable service.

Two new columns have been added on the last page of each *Weekly Weather Report*, showing for each station the Accumulated Temperature of the week, both above and below 42° F.

Two appendices have been given with the *Monthly Weather Report*, viz.: 1. A report by Dr. W. J. Russell on the Impurities in London Air; and 2. Table showing the Mean Monthly and Annual Rainfall at almost all the Stations mentioned in the *Weekly Weather Report* for the twenty years 1866-85. These values are now used in preparing the Daily, Weekly and Monthly Reports.

Land Meteorology of the British Islands.—The volume of *Observations at Stations of the Second Order* for 1881 has been published, and that for 1882 is in hand, in a forward state. The volume for 1881 contains reports *in extenso* on the International Form A. from thirty Stations, including fourteen in connection with the Royal Meteorological Society, and five in connection with the Scottish Meteorological Society; together with monthly means and summaries for thirteen other stations, making forty-three in all, and the monthly duration and percentage of Sunshine at twenty-two stations.

The monthly and yearly Rainfall values from thirty-seven stations have been supplied to Mr. Symons, F.R.S. for publication in his *British Rainfall*.

Returns from ten stations have been supplied each quarter to the Registrar-General for Ireland for publication in his *Quarterly Report*.

The *Quarterly Weather Report* for the year 1877 has been completed.

The *Hourly Readings* for 1883 have been published as far as September and the bulk of the remainder is in type, so that the whole of the year will be completed in a few weeks.

The discussion of the Air Wave caused by the great Volcanic Eruption in the Straits of Sunda in August 1883, has occupied a good deal of time. A series of maps has been prepared to show as far as possible the progress of the wave for intervals of two hours from its origin.

The analysis, by means of Sir William Thomson's Harmonic Analyser, of the records of temperature for the seven Observatories of the Office for the twelve years 1871-1882 has been completed, and the results have been subjected to a somewhat severe series of trials in order to test their accuracy. The result of these tests has been extremely satisfactory; and to mention only one portion of them, it may be stated that they have shown that the mean temperature for a month obtained by the use of the machine may be relied upon as accurate to within five-hundredths of a degree.—*March 30th*, 1886.

ROYAL OBSERVATORY, GREENWICH.—W. H. M. Christie, M.A., F.R.S., Astronomer Royal.—The new apparatus for photographic record of the indications of the dry and wet bulb thermometers having been provisionally mounted under a suitable louvre-boarded shed in the south ground, was brought into regular use at the beginning of the year 1886. It is proposed for a time to continue the records with both the old and new apparatus, for the purpose of making comparison between them. By the introduction of this new apparatus the time scales for all elements both magnetical and meteorological (twelve in number) are now identical. A maximum thermometer, a minimum thermometer and an ordinary thermometer have been mounted in a louvre-screen on the roof of the magnet house, and daily observations with these instruments have been taken since the beginning of the year 1886 for comparison of the temperature indications in this exposed situation with those of the standard thermometers in the magnet ground. The bulbs of the thermometers are 20 feet above the ground.

At the beginning of last year a new eight inch copper rain-gauge was substituted for the old standard eight-inch gauge. The observations with the two other ground gauges were continued as before, thus preserving the continuity of the record.

A Richard thermograph has been provided for use in the magnet basement, principally for more close determination of the small diurnal inequality of temperature of the room.—*February* 1886.

ROYAL OBSERVATORY, EDINBURGH.—Professor C. Piazzi Smyth, F.R.S.E., Astronomer Royal for Scotland.—During the year 1885 the meteorological observations at fifty-five stations of the Scottish Meteorological Society have been calculated at the Royal Observatory, Edinburgh; and the resulting numbers, with remarks upon them, have been communicated to the Registrar-General of Births, Deaths, &c. in Scotland, for that Officer's Monthly and Quarterly Reports, where they have been duly and successively printed.

The Astronomer Royal has also undertaken an inquiry, to ascertain practically whether the Wet-bulb Hygrometer was necessarily so sluggish and imperfect an instrument as many of the returns which passed through his hands seemed to indicate. First of all experimenting at home with the ordinary apparatus, he found it advisable to heighten and enlarge the ventilating chimney of the thermometer box; to provide extra means of warding off solar radiation from three sides and the roof of the box; to decrease the thickness of the muslin envelopes of the wet-bulb, and to test the automatic capillary action of the cotton wick by occasionally pouring water (distilled always) over the bulb, and watching the effect through half an hour. But these little points having been attended to, he was delighted with the sensibility and range of indications of this very simple and now popular form of Hygrometer. Secondly, taking part of the apparatus with him last summer in a tour through Worcestershire, and perambulating therewith both the alluvial valley of the Severn and the heights of the Malvern hills,—he discovered a most marked increase in the dryness of the air on rising above the level of the ordinary *stratus* mists of the plains, whether there was any thing of the kind actually visible at the moment or not; this increase of dryness being of

the same order as, though less in degree than. that which he found thirty years ago on rising above the level of the North-east wind's clouds, some 3,000 to 5,000 feet high, on the slopes of the Peak of Teneriffe. These results, showing both the real innate efficiency of the Wet-bulb Hygrometer when carefully used, and the happy circumstances, in our damp climate, attending the elevated position of Great Malvern, he communicated in a paper to the British Association at Aberdeen last September.

Rain-band spectroscopy has been kept up in Mrs. Piazzi Smyth's private Meteorological Journal as usual, and with many cases of notable advantage in judging of the day's coming weather.

Two extensive papers by the Astronomer Royal on allied subjects, viz. one on the Solar Spectrum, and the other on Gaseous Spectra, one illustrated with sixty, and the other with thirty plates, have been printed by the Royal Society, Edinburgh, and are expected to be published in the XXXIInd. Volume of their *Transactions*, and distributed towards the end of the present month.—*January 8th*, 1886.

THE KEW OBSERVATORY OF THE ROYAL SOCIETY, RICHMOND, SURREY.—G. M. Whipple, B.Sc., F.R.A.S., Superintendent.—The several self-recording instruments for the continuous registration respectively of atmospheric pressure, temperature and humidity, wind (direction and velocity), bright sunshine, and rain, have been maintained in regular operation throughout the year. The tabulation of the traces has been regularly carried on, and copies of these, as well as of the eye observations, with notes of weather, cloud and sunshine, have been transmitted weekly to the Meteorological Office.

The experiments with the photo-nephographs having proved satisfactory, it was decided in June to take frequent pictures for the purpose of determining the rate of motion of clouds. Accordingly the telegraph cable uniting the two stations was buried in the ground, and the stands and electrical fittings were made fixtures. Between July 6th, when the installation of the apparatus was completed, and the end of September, when the experiments were brought to a close in accordance with the instructions of the Meteorological Council, 178 cloud negatives were obtained on twenty-seven days, from these seventy approximate determinations of the rate and direction of motion of clouds at heights varying from 3,000 feet to 70,000 feet have been secured.

The preliminary discussion of the observations made with the six experimental solar radiation thermometers last year having indicated that the completeness of the vacuum in which the black bulb thermometer was enclosed formed an important factor in determining its readings, new jackets with platinum electrodes sealed in them were fitted to all the instruments. These were then, by the kindness of Mr. de la Rue, at his laboratory exhausted to a high degree and sealed hermetically, the vacua being in all cases so perfect that no electric current from a battery of 12,000 de la Rue cells can pass between the platinum terminals, 7 centimetres apart. Two new thermometers have also been constructed on a plan suggested by Professor McLeod and exhausted to a somewhat higher degree. The eight instruments, placed side by side on a stand on the Observatory lawn, have been read and set daily during the greater part of the summer. Comparisons have also been made between their readings whilst submitted to the radiation from a standard Argand gas burner.

Baily's Wind Integrator, after working successfully with electrical counters for some time, was simplified by the inventor, by the substitution of mechanical counters. These being found to work satisfactorily, Mr. Baily removed the instrument in May for the purpose of exhibiting it at the International Inventions Exhibition.

The spare Beckley Anemograph to which the preceding instrument was attached has been dismounted, and together with the de la Rue recorder has, by direction of the Meteorological Council, been reconstructed as a Beckley recorder of the original type.

The Meteorological Council having requested Mr. W. H. Preece, F.R.S., Electrician to the Post Office Telegraphs, to construct an electrical anemometer, and placed at his disposal an old Beckley Anemograph of the 1858 model, that gentleman had it fitted up, and it was erected on the Experimental House of the

Observatory. The velocity attachment has worked satisfactorily for the past six months, neither batteries nor connections having needed attention. The direction gear has, however, occasionally required readjustment of its orientation after strong winds have blown, and is now undergoing alteration.

A number of Hand Anemometers, by means of which the hourly velocity of the wind is determined from an observation extending over two minutes only, have had their scale values determined by direct comparison with the Standard Anemograph of the Observatory.

The number of instruments verified during the past year again amounted to about 11,000.—*January 13th*, 1886.

RADCLIFFE OBSERVATORY, OXFORD.—E. J. Stone, M.A., F.R.S., Radcliffe Observer.—No change in instruments or in the method of observing has taken place during the year 1885.

The anemograph, which had undergone considerable repair in the previous year, has worked satisfactorily. The photographic work, using, as in former years, the waxed-paper process, has been uniformly successful.

Four rain-gauges are in use, two being near the ground, one at an elevation of 22 feet, and one on the Tower of the Observatory at 112 feet. Bright sunshine was registered during 1435 hours out of the 4456 hours the sun was above the horizon, or 31 per cent.

The highest temperature in the air, 85°·8, was recorded on July 25th, the lowest in the air being 23°·1 on December 11th.

During the past year the mean temperature of the air was 48°·5, being 0°·5 below the average for the last 30 years; whilst the rainfall was 25·997 ins., or 0·443 ins. below the average. Between June 25th and August 5th, a period of 41 days, only 0·163 in. rain fell; this deficiency was partially covered by the rainy months September, October and November, when the amounts were 4·392 ins., 3·876 ins. and 3·579 ins. respectively.

A bright solar halo, with parhelia, was seen on December 30th, and a lunar halo with paraselenæ on September 24th.

Weather reports have been supplied daily (by telegram) to the Meteorological Office; bi-monthly to the U. S. Signal Office; monthly to the Registrar-General and the local newspapers; and yearly to Symons's *British Rainfall*, and to some eminent meteorologists by request.

The *Meteorological Results* for 1882 have been printed and distributed, and those for 1883 will shortly be in the printer's hands.

The observations made in 1884 and 1885 are partly reduced.—*January 23rd*, 1886.

CAMBRIDGE OBSERVATORY.—Prof. J. C. Adams, F.R.S.—The meteorological observations have been carried on by Mr. H. Todd as in former years, telegrams being forwarded every morning to the Meteorological Office, and the usual rain record to Mr. Symons. A half-yearly and yearly summary of the observations is also sent to the *Cambridge Chronicle*. No change has been made in the instruments.—*January 12th*, 1886.

STONYHURST COLLEGE OBSERVATORY.—Rev. S. J. Perry, F.R.S.—In addition to the general meteorological reports which have been sent as usual to the Meteorological Office, the Registrar-General, the U. S. Signal Office, and the French Meteorological Society, a monthly report is now published in the *Naturalist*. Special reports are also forwarded to the Upsala Observatory, Mr. Symons, the *Preston Guardian*, &c.

The upper glow continues to be observed with care; the afterglow is seen at intervals; but the day glow is never missing. The intensity in 1885 was quite equal to that of the preceding year.

A paper by Dr. B. Stewart and the Rev. S. J. Perry has been read before the Royal Society on a comparison between the magnetograms of Kew and Stonyhurst.

Sun pictures, 10½ ins. to the diameter, have been secured on 230 days. The drawings of 1883 have all been measured, and those of the other years are progressing fairly.—*January 6th*, 1886.

General Remarks on the Naming of Clouds. By Captain Henry Toynbee, F.R.Met.Soc., F.R.A.S.

[Read February 17th, 1886.]

Having had some experience in training observers to record cloud observations, I am strongly impressed with the fact that it is important to keep to Luke Howard's nomenclature, leaving it to the observer to express by an additional word any peculiarity he notices in a particular cloud.

My custom is to say that the two chief divisions of clouds are into "high" and "low."

These are subdivided into 'threads,' 'rounded lumps,' 'uniform spread' or 'sheet'; and into those from which rain, snow or hail is falling.

It seems clear that Howard did not confine the name of cirrus to hair-like clouds, but intended the term also to convey the fact that the cloud was high; for instance, there is nothing hair-like in cirro-cumulus or in cirro-stratus.

We have then the following names for high clouds:—

Cirrus.—A thread or hair-shaped cloud.

Cirro-Cumulus.—Small, high, rounded masses.

Cirro-Stratus.—High uniform sheet or patches.

And the following names for lower clouds:—

Cumulus.—Low (though sometimes reaching to a great height) large rounded masses.

Cumulus (small).—Low but small rounded lumps.

Stratus.—Low uniformly spread sheet or patches.

Nimbus.—Low or high masses of cloud from which rain, snow or hail is falling.

Now it is manifest that there are at times clouds which are intermediate between the cirro-cumuli and the small cumulus; and others which are intermediate between the cirro-stratus and stratus. To meet such cases it seems best to leave it to the observer to decide which class the cloud he sees is most like, and to add high or low to its name; for instance, a cloud between cirro-cumulus and small cumulus may be recorded as low cirro-cumulus, or as small and high cumulus. The same method might be followed with a cloud which was intermediate between cirro-stratus and stratus.

Again, a cumulus-shaped cloud may appear to be softer than an ordinary cumulus, and it may be recorded as soft cumulus. The same may be done in the case of cirro-cumulus when it has a soft appearance.

Then again, cirro-stratus and stratus sometimes appear in separate patches instead of in sheets, in which case (detached) can be added to their names.

Lastly, varieties of the nimbus might also be distinguished by words such as, slight, or heavy.

Howard also gives the name of cumulo-stratus, which, according to his illustration, is a heavy looking cumulus having generally a dark flat bottom with one or more layers of stratus or cirrus about its sides or top. This cloud is worthy of a special name, as it is intermediate between cumulus and nimbus,

and is a sign of the breaking up of fine weather and of the failing of a steady wind; it is very commonly met with at the equatorial margin of a Trade-wind. Observers of the present day seem inclined to give this name to a cloud which is somewhat intermediate between a cumulus and a stratus, but I would suggest that the appearance of such a cloud is fairly expressed by soft cumulus.

The above names are all given by Luke Howard, and with the additional words suggested they seem to meet all the distinctions which can be expected from ordinary observers. Until our cloud observers have discovered another cloud which has a distinct appearance and is always accompanied by an important type of weather, I would not add another name to Howard's list.

Although not related to the naming of clouds, it appears to me that, considering the difficulties there are in placing wind-vanes and anemometers, it would be well to ask observers at land stations to record the apparent speed of the lowest clouds, the direction from which they are moving, as well as the same facts respecting cirrus which are already asked for. Their speed might be expressed by three figures, thus: 1 slow, 2 moderate, 3 fast; a dash under the 3 might represent very fast. I am keeping such a record daily, and find it easy and helpful.

DISCUSSION.

The Rev. W. Clement Ley, in a communication to the Secretary, said:—"I deeply regret that I have to express my entire disagreement with the conclusions come to by my valued friend Capt. Toynbee, in the paper which has just been read before this Society. When one to whose opinions on all matters of meteorological observation so much deference is due records his determination to keep to Luke Howard's nomenclature of clouds, some of those who expect progress in a useful and important branch of weather knowledge must express regret.

"Before the dawn of synoptic meteorology Luke Howard's system filled a need, though it did little to promote inquiry. Since that era it may safely be made the basis of a carefully discriminating and eclectic system of terminology. But any endeavour to restrict ourselves to its use, cuts off the possibility of obtaining what becomes more and more necessary, viz. the power of either communicating from distant localities the actual aspect of the sky, so that this may be represented synoptically, or of recording such an aspect in a journal so as to call up any vivid idea of the observed phenomena to the reader of the journal. I believe that ten thousand years of observations conducted on Luke Howard's system (adhered to without improvement) would give us an absolutely futile record.

"I am too well aware that the title *cirro-cumulus* is commonly given to any patches of stratiform cloud when seen somewhat near the zenith, because such clouds are structurally composed of nubecules detached from, partially united to, or welded with, one another, and that such cloud commonly acquires the name of *cirro-stratus*, or *stratus* (at the option of the observer), when it is seen near the horizon. But none of the destructive criticisms which I have ever offered to Howard's terminology appear to me equal in severity to those of the author of this paper. For I should hesitate to say that Luke Howard himself intended to apply the name of *cirrus*, or the prefix *cirro*, to clouds in which there is nothing 'hair-like at all.'

"Then what is to be said for the title *nimbus?* A snow-shower falling from a patch of cloud less than 1,000 feet in thickness, a massive hail-cloud several miles in height, but perhaps of exceedingly circumscribed area, the steady rainfall of a composite cloud-bank extending over 40,000 square miles or so of the earth's surface, are all to be comprehended under a single name. Our own language is to be congratulated for the non-possession of so comprehensive a term.

"As for *cumulo-stratus*, it is a name destined I believe to be retained, but I hope that its unhappy associations will be forgotten. At present I know of no cloud excepting actual *cirrus* to which the title *cumulo-stratus* is not applied by one or other observer, and so entered in reports which are treated as of scientific value. A *cumulus* spreading out into layers of stratus about its summit, as contrasted with a *cumulus* spreading out into a really cirriform crown, is, as I believe, rather the sign of the continuance than the breaking up of fine weather. The confusion, however, between these two types of cloud was scarcely so much due to Luke Howard himself as to his illustrator, and for the ever-ramifying confusions which have subsequently developed themselves later observers are responsible.

"I have the authority both of the Hon. R. Abercromby, now I believe occupied in stalking cyclones in the East, and of other acute observers who have travelled widely, for the statement that clouds are to all practical purposes similar all over the world. I believe that local varieties can be counted on the fingers of one hand. Clouds are objects that lend themselves with some facility to classification. But such classification must be based essentially on structural differences and the physical processes which produce them, if it is to acquire the utility which is possible in synoptic meteorology, and in the diagnosis and prognosis of weather."

Capt. D. W. Barker considered something simpler than the Rev. Clement Ley's classification of clouds was required for the use of ordinary observers, and thought that if Capt. Toynbee's simple classification were made more generally known a satisfactory solution of the cloud question might be arrived at. He (Capt. Barker) favoured a still more simple classification. Observers were commonly falling into error in calling clouds by wrong names, the *cirro-cumulus* particularly; all sorts of *stratus* being commonly noted as *cirro-cumulus* instead of *stratus*. It would also be a good thing if observers recorded the velocity of clouds in the way suggested by Capt. Toynbee. He kept a record of cloud velocities on this plan, and found it to be very useful.

Mr. Archibald said that Capt. Toynbee's classification could be used by some persons where the number of Mr. Ley's definitions would be too great, but he thought the chief thing to be considered was the object of the observations, whether they were for use in a scientific investigation or not. He was of opinion that three classes of cloud would be sufficient for observation at sea, and that the *nimbus* form might be dispensed with. He was glad to see *cumulo-stratus* absent from Capt. Toynbee's list, as he believed there was a great deal of confusion among observers respecting this class of cloud. It was very desirable that in future the scientific nomenclature of clouds should be based not merely on structural differences, but also on their differences of altitude. Each variety of cloud had its own level, and it certainly was essential that this should be taken into consideration in the classification of cloud forms for scientific purposes. For ordinary observations, however, something simpler would suffice.

Dr. Tripe objected to Mr. Ley's cloud names, as being too numerous and too complicated, and, to a certain extent, failing to convey a definite idea of cloud form. For ordinary purposes he thought that something simpler was desirable, and the fewer the names within certain limits the better. Two years ago he remembered seeing a magnificent *cumulus* cloud moving from West to East across a perfectly clear blue sky, and in its passage he observed little pieces being as it were torn off the top of the *cumulus* cloud and left in its trail by a fierce wind blowing from East to West. The track of this cloud was marked along the sky by the thin wispy hair-like pieces of cloud which covered the sky behind and could only be called *cirrus*. He thought as there are two distinct forms of *cirrus* clouds at different heights, which are formed by different causes and are in different states, *i.e.* one ice and the other vapour, they should be differently named.

Mr. Scott said that at the Meeting of the International Meteorological Committee held in Paris last year, Prof. Tacchini had made some remarks similar to those just uttered by Dr. Tripe, and Prof. Hildebrandsson had replied that he usually called these low *cirrus* clouds "false *cirrus*," in order to distinguish them from real *cirrus*. It had also been frequently remarked that no rain or hail fell from a *cumulus* cloud unless these streaks of "false *cirrus*" appeared above it.

Mr. WHIPPLE suggested that the time had arrived when the Society should appoint a Committee to inquire into the question of cloud classification and nomenclature. He thought a standard diagram of cloud forms should be decided on, as he believed that observers were chiefly guided by diagrams in the recognition of cloud forms, and the only good diagram at present readily accessible was that issued by the Meteorological Office. It would be a good thing for the Society to prepare a standard diagram representing the various typical cloud forms, in order to meet more modern ideas than those of Luke Howard. It was certainly desirable that an uniform system of cloud observing should be established.

Mr. SYMONS said that the nomenclature of clouds was a large and difficult question, and he doubted if the time had arrived for any one Society to undertake a settlement of the question. He thought the International Meteorological Committee was the proper body to deal with the subject. It was well to remember that a number of scientific men were working at this subject, and the more advisable plan to follow would be to let them continue their researches for some time longer, so that when a settlement is effected it should be a lasting one.

Capt. TOYNBEE said, in reply to Mr. Ley, that he did not wish to throw cold water on the work of those who, like Mr. Ley himself, were making a special study of the clouds; far from doing so, he wished that more would take up the subject. Where he differed from Mr. Ley was in his desire to keep to the few well-known broad types, and to express differences by an explanatory word or two, which could not be mistaken by ordinary observers; instead of giving a new name and sketch for each grade of difference. His opinion was, that cloud observing is difficult to ordinary observers, and that no new cloud-name should be accepted until it could be shown to represent a cloud which could be easily distinguished from other clouds, and which was related to an important type of weather. He quite agreed with Mr. Symons, who thought that the time had not yet come for a Committee to be formed to consider the naming of clouds, but that a good deal more work was needed from cloud observers; he therefore did not agree with Mr. Whipple's proposal. Capt. Barker's remark as to the appearance of *cumulo-stratus* with the North-westerly wind after a Northern Hemisphere Cyclone, when the weather is about to improve, was in accordance with his own remark that *cumulo-strati* appear in the equatorial regions between a steady Trade and the Doldrums. They are a sign of change of weather either from settled to unsettled, or *vice versâ*. In the neighbourhood of a doldrum the change of weather, from settled to unsettled or *vice versâ*, depends on which way the ship is going, as the doldrum changes its position very slowly; whilst with the cyclonic systems of high latitudes, the change of weather depends chiefly on the track and speed of the system itself, though a ship's course and speed have much to do with it.

ON THE THICKNESS OF SHOWER CLOUDS. By ARTHUR W. CLAYDEN, M.A., F.G.S., Bath College. Communicated by WALTER BAILY, M.A., F.R.Met.Soc.

[Read February 17th, 1886.]

No doubt most people have noticed that there is some connection between what is called the "blackness" of a cloud and the heaviness of the shower which falls from it. Now "blackness" is roughly proportional to thickness; so I have been led to make a number of measurements of the thickness of shower clouds, to see if the popular impression rested on any scientific basis.

The first step was to find some method of ascertaining the height of the base of each cloud above the ground. The methods employed at Kew and Upsala had not been made public when I began my observations, nor indeed could I have easily availed myself of them, having to work alone. The

means I adopted give a result which, when applied with sufficient care, is accurate enough for the immediate purpose in view, especially when the ill-defined surfaces bounding a cloud are taken into consideration. The method is dependent upon intervals of sunshine and the presence of clouds so dense as to throw a fairly sharp shadow; conditions which militate against its general value, but which do not interfere seriously with the special object in view, namely the measurement of cloud thickness; this from its very nature necessitating sufficient breaks in the cloud stratum to enable its upper surface to be seen.

The instruments required are an azimuth compass and a sextant.

If the observer stand at some spot not much above the level of the surrounding country, but from which he can command an extensive view, he will find that as the clouds pass over on an ordinary showery day with bright intervals between them, he will have no difficulty in selecting some corresponding points of cloud and shadow. He will not be able to do so with every cloud, but unless the conditions are very unfavourable he will not have to wait long.

Supposing both cloud and shadow to be approximately equidistant from a vertical plane drawn through the observer at right angles to that in which the sun lies; then both cloud and shadow will be in a plane at right angles to the direction in which the observer looks, and the shadow and the point vertically beneath the corresponding part of the cloud will be equally remote from him. Now let the position of some part, say the furthest edge, of the shadow on the landscape be noted, a horizontal line rapidly traced from this point until it comes under the cloud, and the angle between this and the corresponding part of the cloud measured with the sextant. I am aware that these directions sound vague, but it is easy with a little practice to follow them rapidly, and to make the measurement of the angle three or four times consecutively with only a very small percentage of error.

Let B be the observer, A the point of the cloud, and C the point vertically beneath A; then

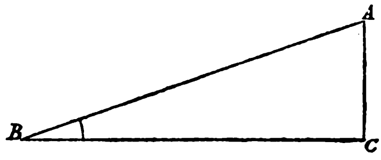


FIG. 1.

$$AC = BC \tan. ABC,$$

of which BC is equal to the distance from B to the point of shadow whose position on the landscape has been noted. This distance is easily found by direct measurement on a good map.

Next suppose the sun and the cloud to be in the same vertical plane with the observer. Let A be the point of the cloud, C the corresponding shadow, B the observer and D the point vertically beneath A. In the triangle A B C,

the angle A B C is measured; and the angle A C B is the same as the angular altitude of the sun above the horizon, so that is measured. Note the position of C and measure A B C,

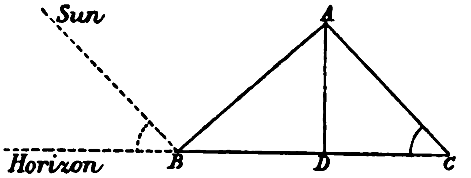


FIG. 2.

$$\text{Then AD} = \frac{\text{BC sin. ACB} \times \text{sin. ABC}}{\text{sin. BAC}}$$

BC is found, as above, by reference to the map.

Finally, in case neither of the above methods can be adopted owing to the required positions being unattainable, a measurement can still be obtained. The method is slightly more difficult to use, but if the clouds are not moving rapidly it gives an equally exact result.

Let A be the point of the cloud, C the corresponding shadow, B the observer, BH and CH′ two horizontal lines in the same vertical planes with the two parallel rays from the sun SB and S′AC respectively.

With the compass measure the angles HBE and DBC; and with the sextant measure the angle ABD. Note the position of C.

From HBE we get DCB, and from DCB and DBC we get BDC.

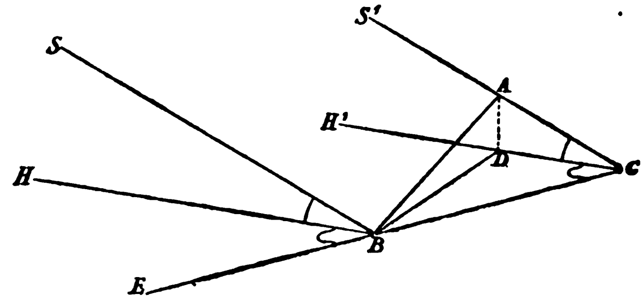


FIG. 3.

$$\text{Now BD} = \frac{\text{BC sin. BCD}}{\text{sin. BDC}}$$

$$\text{but AD} = \text{BD tan. ABD}$$

$$\text{therefore AD} = \frac{\text{BC sin. BCD} \times \text{tan. ABD}}{\text{sin. BDC}}$$

By carefully selecting a favourable opportunity and employing one or the other of the three methods given above, I have seldom found three or four determinations of the height of the same cloud depart so much as five per cent. of the whole from their mean,

It will at once be noticed that the most common form of shower cloud is roughly pyramidical, having a broad flat base, and that if a number of such clouds are visible at the same time, their bases all lie in the same horizontal plane, which might be conveniently designated the "cloud-line." Moreover, this cloud-line only alters its altitude somewhat slowly, remaining practically constant for an hour or sometimes very much longer. Hence, if a reliable determination can be arrived at with one cloud, the height of the base of any other cloud in the same stratum may be assumed to be the same if the interval of time has not been great.

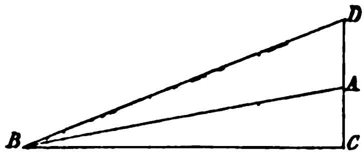


FIG. 4.

To measure thickness, let D be the summit of the cloud, A a point in its base as near as can be judged vertically beneath D, C the point on the horizon beneath this, and B the observer. Then DC, the height of the summit, is to AC, the height of the base, as the tangent of the angle subtended by DC is to that subtended by AC. But AC has already been ascertained—

$$\text{Hence} \quad AD = \frac{AC \tan. DBC}{\tan. ABC} - AC$$

So that all that is necessary is to measure the two angles DBC and ABC.

It is hardly needful to remark that a single measurement should only be accepted when confirmation is impossible.

In the following table every measurement has been checked by two or three repetitions, and the greater number of them are the mean results deduced from five or six determinations. They were made between the beginning of April and the end of September 1885, whenever a good opportunity could be taken advantage of.

No. of Clouds observed.	Height of Base. feet.	Thickness. feet.	Character of Drops falling from Cloud.
14	700—2,000	600—1,900	None
2	1,000—1,100	800	Very small
6	1,000	1,000	Small
1	1,900	1,000	Small
2	1,100	1,200	Small
3	1,000	1,500	Small
3	1,200	1,800	Small
4	1,200	2,000	Small
1	900	2,000	Small
3	1,300	2,200	Medium
4	1,000	2,500	Medium
3	1,200	3,000	Medium

No. of Clouds. observed.	Height of Base. feet.	Thickness. feet.	Character of Drops falling from Cloud.
2	1,400	4,000	Large
1	1,500	4,100	Rather large
1	1,200	4,200	Large
2	1,400	4,400	Large and cold
2	1,700	5,000	Large and cold
1	1,800	6,000	Large and hail
1	900	6,100	Very large
1	900	7,900	Hail
1	1,800	10,300	Heavy hail, hard frozen.

Many other measurements have been made, but being isolated observations they have been omitted, although they entirely agree with the above.

It will be noticed that when clouds of the type called shower clouds have a thickness of less than 2,000 feet, the rain will be slight; and that as the raindrops increase in size and decrease in temperature the thickness of the cloud also increases; until the clouds from which hailstorms come may reach a thickness of over 10,000 feet.

On the Formation of Rain, Hail and Snow. By Arthur W. Clayden, M.A., F.G.S., Bath College. Communicated by Walter Baily, M.A., F.R.Met.Soc.

[Read February 17th, 1886.]

Some measurements made by me during the summer[1] of 1885 have derived the following conclusions, viz. That clouds of less than 2,000 feet in thickness are not often accompanied by rain; and if they are it is only very gentle, consisting of minute drops. With a thickness of between 2,000 and 4,000 feet the size of the drops is moderate. As the thickness becomes greater the size of the drops increases, and at the same time their temperature becomes lower, until, when the thickness is upwards of 6,000 feet, hail may be produced.

Thus—

No. of Clouds observed.	Height of Base. feet.	Thickness. feet.	Character of Drops falling from Clouds.
14	700—2,000	600—1,900	None
22	900—1,900	800—2,000	Small
10	1,000—1,800	2,200—3,000	Medium
4	1,200—1,500	4,000—4,200	Large
4	1,400—1,700	4,400—5,000	Large and cold
1	1,800	6,000	Large and hail
1	900	6,100	Very large
1	900	7,900	Hail
1	1,800	10,300	Heavy hail, hard frozen.

[1] See Paper on the *Thickness of Shower Clouds*, p. 102.

These facts point to the conclusion that the great thickness, or rather perhaps altitude of the upper surfaces of the three clouds from which hail was observed to fall, had some connection with its formation. In the last case the hailstones were quite opaque, about ½ inch in diameter and ¾ inch in length; so cold that they did not begin to thaw for several minutes after they fell, although the temperature of the air shortly before the storm had been 55°. They were so soft that a handful of them could easily be compressed into a kind of snowball. Finally, they showed a sort of radiated structure, as if minute needles of hoar-frost had formed around a solid nucleus.

My own conclusions fit in so exactly with popular impressions that I have naturally been led to inquire whether an explanation may not be found which shall account for the facts.

First—What is a cloud? No doubt it will be generally admitted to be a portion of the atmosphere saturated with water-vapour, and containing a large number of particles of true liquid water. It may not be out of place to remark here that if there be any truth in the suggestion that the ultimate particles of liquid water are small groups of the true gaseous molecules, it may well be that the particles peculiar to cloud and mist are such groups. Be this as it may, there is little doubt but that the essential cloud-particles are true liquid, and that they are suspended in a saturated atmosphere.

It seems usual to explain the formation of rain-drops by supposing these cloud-particles to collide and run together until the resultant drop is large enough to fall. Now it is difficult to see how such a conjunction can be brought about, and no explanation is offered as to why no rain whatever falls from clouds of greater thickness than others from which an abundant drizzle comes; nor is it possible to see why all the drops of a heavy storm are large. Finally, the connection between cloud thickness and the character of the precipitation is scarcely explicable.

When a vapour is cooled by its own expansion consequent on a diminution of pressure, as in the receiver of an air pump, it assumes the form of mist, minute liquid particles being formed throughout the mass. Hence, if a cloud were cooled by expansion consequent on a rise in altitude, the only result would be the formation of more cloud-particles from its saturated atmosphere. So far as the present state of our knowledge goes, we have no reason to conclude that such a mode of cooling could bring about the formation of a drop.

Suppose, however, that some of the liquid cloud-particles are cooled, say by radiation, to a temperature ever so little below that of the saturated atmosphere surrounding them; the result must be similar to that of the introduction of a cold body into a warm, damp room. That is, a film of moisture will condense all round it, or rather, other liquid particles will be deposited upon it, until the heat evolved from the condensation has warmed the mass up to the temperature of the surrounding air.

Such a preliminary loss of heat by radiation cannot easily occur at the base of the cloud, where the particles would rather tend to gain heat from the earth; nor would it be likely to take place within the cloud, owing to the

adiathermic atmosphere; but at the upper surface it is just what we should expect to find, the particles radiating their heat to the cold upper regions of the air. It may be objected that this upper surface would also be most rapidly warmed by the solar heat, but the objection is of little weight, because just those solar rays which would warm the transparent particles most rapidly will have been already absorbed by the upper regions of the atmosphere.

All observations tend to show that, except under quite abnormal conditions, the temperature of the atmosphere falls as the height above sea-level increases; and there seems no reason whatever for assuming that the law does not apply to that portion of the atmosphere which forms a cloud. Hence, if a drop be formed, as is suggested, at or near the upper surface of a cloud, it will descend into a region saturated with vapour at a temperature above its own. The result will be further condensation producing a larger drop; and this process will continue until it leaves the cloud. If its temperature is below the dew-point of the air through which it falls, condensation will continue until it reaches the ground. However, it is obvious that this subsequent gain cannot bear any very large proportion to its growth while falling through the saturated cloud, from which the conclusion follows that the size of the drop must increase with the thickness of the cloud.

Now the velocity with which the drop will fall is slow at first, increasing rapidly until it reaches a certain maximum. Hence it will move faster as it traverses warmer regions, and will not have time to come into thermal equilibrium with one stratum before it has passed on to another warmer still. It thus follows that the temperature of the drop as it leaves the cloud, especially if it be large, will be lower than the average temperature of the cloud; and as this is dependent on the respective temperatures of its base and upper surface, the drop must become colder as the thickness of the cloud increases.

Suppose the first minute drop were formed at so great a height that its temperature were to be below 32°, it is not necessary to suppose that it would solidify. On the contrary, as Despretz, Dufour and others have shown, such minute drops may be cooled to $-4°$ without freezing. Such an intensely cold drop will fall slowly, growing from the effects of condensation until it is large enough to freeze. It will then solidify, its temperature rising to 32°, and will be a small rounded particle of ice. If it is still above the snow-line it will cool below 32°, and subsequent condensation will be frozen around it until its temperature reaches the freezing point, after which it will begin to thaw, and the nucleus of ice will be surrounded by a layer of ice-cold water until it is all melted. Under these circumstances a hailstone will be first formed, which will generally consist of a nucleus of ice with a wet and partly thawed exterior. But if the hailstone is cold enough when it crosses the snow-line it may reach the ground before its temperature has risen high enough for thawing to begin. In such a case the hailstones would be hard frozen and dry, such as those which fell during the storm in which the observations quoted last in the table were made.

It will be noticed on reference to the table that all the clouds from which hail has been observed to fall reached a height of 7,000 feet. The snow-line

over the South of England is probably somewhere between 6,000 and 7,000 feet above sea-level; so it is seen that in all cases of hail that I have been able to measure the upper surface of the cloud most probably had a temperature below 32°.

If the original cooled particle be sufficiently cold it will solidify before condensation begins, and subsequent additions to it will pass direct from the state of vapour to that of the solid, so forming a crystalline snow-flake. This will increase in size until it reaches the snow-line, but will not attain any great velocity owing to its feathery form. The slow fall will have one very important result, namely, that the temperature of the flake will have time to all but adjust itself to that of each stratum of air as it passes through it; unless, owing to some unusual cause, the temperature of the air fall more rapidly with the altitude than ordinary. In either case, when it passes the snow-line, it will condense water from the warmer parts of the cloud upon itself, this water freezing around the crystals and partly destroying their crystalline form, until the temperature of the mass has reached 32°. In the immense majority of cases this will soon take place owing to the large surface, but in the rare exceptional instance indicated above, the addition of ice might quite destroy the crystalline form. Indeed the fall of irregular masses of ice, neither exactly hail nor exactly snow, may not impossibly be accounted for in some such way. When such flakes or ice lumps descend through a warm atmosphere they will rapidly thaw, so producing a fall of either sleet or cold heavy rain.

It is thus suggested that condensation begins on the upper surface of the cloud by the cooling of some of the liquid cloud-particles. If one such particle be cold enough it will solidify, and snow will be formed. Should it not be quite cold enough to solidify at once, owing to its minuteness, but remain still below the freezing-point, hail is formed. Finally, if the temperature be not low enough for either snow or hail, rain is produced.

Of course it is impossible to give an exact definition of either hail or snow. They pass through a great variety of intermediate forms from one to the other. The typical hailstone is a hard semi-transparent piece of ice, not very much unlike what a frozen raindrop would be; while the typical snowflake consists of the well-known six-rayed crystals. But hail is often quite opaque and of a somewhat spongy texture, strikingly like a little ball of hoar frost; and snow frequently falls in very similar little rounded balls. In winter people often give the name of snow to what they would not hesitate to call hail in the summer. The facts point irresistibly to the conclusion that both have a common origin, differing only in degree.

If the original cooled cloud-particle be sufficiently cold to solidify as soon as it is large enough to form one of the ultimate particles (molecules) of the solid, a true snow-crystal should result. If, on the other hand, it cannot solidify until a distinct drop is formed, hail should be produced. Should it solidify at any intermediate size some intermediate form should follow.

As we rise above sea-level the temperature steadily falls until we reach the snow-line, above which the temperature remains always below 32°. At a still

greater height we shall reach another line above which the temperature will always be below that at which the cloud-particles will solidify on cooling. Hence it is possible to divide the atmosphere at any given time into three zones: first, that in which the conditions are those required for the production of rain; second, that in which the conditions would form hail; and lastly, that where snow would originate. Let us call the intermediate zone the hail zone.

Now temperature falls with increased altitude most rapidly nearest the Poles, and least rapidly near the Equator. From this it follows that the hail zone will be very thin in Arctic and Antarctic regions, so that if hail were formed at all the hailstones could only be so very small as to escape recognition as such.[1] On the other hand, where the hail zone is very thick, hail will be formed most often and the hailstones will reach the largest size. In temperate climes the summer conditions approximate those near the Equator, and in winter the circumstances are more like those near the Poles. It is thus seen that we should expect hailstones to be the largest and most frequent in tropical countries; more abundant in summer than in winter in temperate climates; and almost unknown in very high latitudes; showing a complete accordance between theory and fact.

Hail is rare on the lowland plains within the tropics, probably because it is seldom that a cloud rises sufficiently high to reach the hail zone; and when it does do so it will be still more seldom that the hailstone will be cold enough to pass through all the 18,000 feet of air above 32° without melting. It is particularly large and abundant on tropical table-lands, because there the hail zone is at its maximum thickness, and there is no greater thickness of warm air to fall through than there is in temperate zones.

Hailstones often show a somewhat concentric structure, film after film having been frozen around the central nucleus. Sometimes the central portions are opaque, as if the earlier part of the condensation had been deposited round the cold nucleus in the form of hoar-frost; while the external parts are more transparent, as if there the ice had passed through the liquid state. It will at once be seen that these facts are what we should expect if the proposed theory were correct.

In a given hailstorm all the hailstones which fall within a few yards of each other, and within a few seconds of time, resemble each other so strongly as to show that there must have been some common factors in the causes which produced them; and that their peculiarities cannot possibly have been brought about by accident, such as the collision of two and their freezing together.

It seems usual for the authors of books which bear upon this subject to speak of the formation of rain as if it were simply a step further than cloud in the condensation of vapour. If the temperature at which this further condensation takes place is above freezing-point, rain is formed; if below, snow.

[1] On the morning of December 10th, 1885, there was, in the neighbourhood of Bath, a slight fall of what every one called snow; but it consisted of numbers of round particles of clear transparent ice, varying from $\frac{1}{25}$ in. to $\frac{1}{16}$ in. in diameter. That is, it was really very fine hail.

No attempt is made to say how condensation is brought about, nor to explain the formation of large and small drops. They then speak of hail as if it were rather an inexplicable phenomenon, and endeavour to account for it either by calling in the aid of some vague electrical action, or by supposing that drops of rain in falling from a height traverse a stratum of air so intensely cold as to freeze them bodily.

The electrical theory is supported by the fact that thunderstorms are often accompanied by hail. But thunder often comes without hail; and hail is often unattended by thunder. Moreover, thunderstorms are especially frequent in just those lowland tropical plains from which hail is generally absent.

The frozen rain-drop theory makes no attempt to explain the peculiarities of structure often seen in hail, and it seems impossible to see how they arise if that theory be true. Again, the supposition of the cold stratum below a warmer one, although perhaps not altogether contrary to experience, is certainly uncommon, and it is extremely difficult to conceive such a stratum existing without showing any trace of its presence by a line of cloud or something of the sort. It seems that hail would have to be formed when there were several layers of cloud above each other, a condition which is certainly not satisfied during very many hailstorms. It is a matter of fact that hail clouds differ in no particular from rain clouds except in that their upper surfaces reach a greater altitude.

In the theory which it is the object of this paper to lay before those best qualified to discuss such a question, no assumptions have been made which are not in strict accordance with fact; it explains, so far as is possible in a short space, numerous peculiarities not approached by any theory before the public; and finally, it shows that the common phenomenon of hail requires no exceptional conditions of the distribution of temperature in the atmosphere, nor indeed any others than a graduated difference of degree from those which would produce the yet commoner phenomena of rain, snow and sleet.

DISCUSSION.

Mr. G. Dines said he had at different times thrown out suggestions as to the formation of rain drops, but could never muster up courage to write a paper on the subject. It was a most difficult question, and he felt that a great part of what he might say was little better than mere conjecture. He should confine his remarks to the formation of rain-drops. There were strong arguments against the theory advanced in the paper that the drops were formed by condensation. When condensation of vapour took place heat was set free, and part of this heat might pass into the outside air, but he had little doubt that a great part would be received by the drop and would soon warm it up so as to stop condensation. Sir John Herschel had written a paper on the subject, but he (Mr. Dines) had not seen it, he therefore referred to Mr. Symons's summary of it. This would be found in a paper[1] read at the British Association Meeting at York, which paper had been the means of removing one great stumbling block out of the way of meteorologists. The words used by Mr. Symons were these:—"The theory that the growth of the rain-drop by the condensation of particles of vapour floating in its path was adequate to explain the elevation difference was demolished by Sir John Herschel, who showed that the latent heat of steam,

[1] See *Symons's British Rainfall* 1881, page 43; also Sir W. Thomson's Remarks, page 45.

being about 1,000° F., drops of rain, if they acquire an increase of weight amounting to 1 per cent. by condensed vapour, must in so doing have their temperature raised 10°. If they acquire an increase of 5 °/₀, they must have their temperature raised about 50°." These words were rather strong against any condensation theory.

If the Fellows referred to his (Mr. Dines's) paper on Evaporation,[1] it would be seen how slow the process of condensation was upon the surface of ice. He had repeated the experiments on Monday last; the results might be put as follows:—If a ball of ice were suspended in the room, it would take from fifteen to twenty minutes to increase its diameter 0·001 in. by condensation. On this point he spoke with some certainty. The lower the temperature, the slower the condensation. He was well aware that the surrounding circumstances were different—a rain-drop was in motion, he did not know how long it was falling to the earth; but notwithstanding these differences, he looked upon it as almost an impossibility that rain-drops could attain to the size they did by condensation.

He had made observations as to the temperature of rain—on one occasion when there was a considerable quantity of hail mixed with the rain, he was surprised to find the temperature 54°. He had seen it as high as 70°. He could not recall any instance when the temperature had been below that of the dew-point, but more frequently than not it was above that of the air. He could only account for these high temperatures by supposing that the rain was warmed by its friction through the air, and by the stoppage of its motion. If this were so, it gave back to the earth a part of the heat that had been taken away by evaporation; at all events it showed that there would be no condensation on the rain-drop for some time before the drop reached the earth. On one point they were agreed, namely, that all the rain which fell upon the earth must at some time or the other have left it in the form of vapour. As the saturated air left the earth, it was cooled by the work which it performed in expanding, and a part of the vapour was converted into water and formed cloud.

By passing a fixed quantity of air through sulphuric acid, he had endeavoured to find what quantity of these clouds or water particles were held in suspension by the air. Taking a fog cloud (when the temperature was generally low), it did not exceed one grain in weight per cubic foot of air. In a dense cloud like that made in a laundry on washing days, when the temperature was about 70°, it had at times amounted to three grains. From some observations which had been recently made by his son, Mr. W. H. Dines, F.R.Met.Soc., he was inclined to think these amounts were under estimated, as sulphuric acid did not dry the air so rapidly as was generally supposed. As the temperature of the air increases, it is enabled to hold a greater quantity of vapour without being saturated. (Query—Does anything of this kind apply also to the particles of water held in suspension by the air; and if so, is there any limit in the latter case as in the former?) His next attempt was to get at the size of these water particles. For this purpose he used a small brass vessel, fitted to the stage of his microscope, through which cold water was made to circulate so as to keep the surface just above the temperature of the dew-point; as the drop fell the size was easily ascertained by placing a micrometer in the eye-piece.

In a fog cloud the sizes of these particles were very irregular, some as large as 0·045 in. in diameter,—these fell sufficiently fast to be flattened by their fall. In the laundry, where the air was comparatively still, the drops, or rather particles of water, were much smaller and more even in size; he estimated the diameters to be from 0·00033 to 0·00025 inches. In making these observations an unexpected sight presented itself; he had on several occasions seen these small drops or particles of water floating in the air, they were in motion, both horizontally and vertically, but the motion was so slow that they remained in the focus of the object glass long enough to get a good view of them before they touched the stage. By calculation he found that it would require about one thousand millions (1,000,000,000) of these drops to make up three grains in weight. It appeared to be almost incredible that a cubic foot of air could hold this number of perfect water drops in suspension, but he did not think he had over-estimated the amount.

The theory which he had formed in his own mind as to the formation of rain-drops, but which he did not for a moment consider as original, was this. Supposing

[1] *Proceedings of the Meteorological Society.* Vol. V. page 201.

the diameter (d) of one of these small drops of water to be increased by collision with other drops, the surface which would have to encounter the friction of the air in its passage downward would be as d^2, whilst the weight of the drop to overcome that friction would be as d^3. Roughly speaking the power of the drop to force its way downward would be in proportion to its diameter. As the drop increased in size, and its velocity increased, it would come into contact with a greater number of the watery particles floating in the air. Increased velocity in the drop would cause increased friction, but there was little doubt the larger the drop the faster it would fall, and if he could transport himself to the under-side of the rain-clouds, some miles in depth, he should expect to see rain-drops of all sizes emerging from the clouds, the smaller ones just struggling through, and others moving downwards with considerable velocity. He, like the author of the paper, had not called in electricity, that most useful refuge for all doubtful meteorological theories, but if it could be supposed that these small particles of water were attracted to each other either by electric or capillary attraction it would simplify the matter. It was generally allowed that clouds were in different electrical conditions, and if this brought them in any way into collision, the clashing of the drops together would be accelerated, and help to account for the large drops of rain which came down with thunder showers. The snow line was assumed to be 6,000 to 7,000 ft. high over the South of England; this might be correct as far as the surface of the earth was concerned, and also with regard to the atmosphere on a clear day, but at night and when the sky was clouded this rule for the decrease of temperature with elevation did not always apply, and in one of Mr. Glaisher's balloon ascents (the 18th) he found the same temperature (46°) at 10,000 feet above the earth as on the ground. This was another argument against the condensation theory. With regard to the depth of the rain clouds, he (Mr. Dines) had often wondered where all the rain came from. If three grains of water were allowed per cubic foot, it would take clouds of about three miles in depth to produce an inch of rain. It was true there was a reservoir left in the vapour of the air, but this was small in amount at low temperatures, and he did not see how it could be made available, and for this reason he was led to think that the depth of the cloud had been under-estimated in the paper.

The Rev. W. Clement Ley, in a communication to the Secretary, said:—"As an old observer who has spent a great part of his life in the estimation of the altitudes and velocities of clouds, I wish to welcome Mr. Clayden's two papers as of remarkable interest. With Mr. Clayden's general conclusion as to the relation between the thickness of shower-clouds and the character of the precipitation taking place from them I fully agree. A longer experience will, however, I think convince him that his scale of altitudes will have to be increased in a very great degree indeed, in order to take in cases of no very uncommon occurrence, even in our own latitudes. I notice that his observations were made between the beginning of April and the end of September 1885. They thus comprise no winter observations. For this reason the lowest limits both of the bases and thicknesses of shower-clouds do not appear in the table. During frosty weather in winter, slight snow showers not uncommonly fall from clouds whose base is somewhat less than 1,000 feet above the earth's surface, and whose vertical thickness is less than 400 feet. Drizzling rain also occasionally falls from clouds of similar altitude and thickness, especially over the sea. As regards the other limit of the table, it should be noted that the observations were made in a season remarkable for the almost total absence of those shower-clouds of the greatest altitude, which constitute our heaviest thunder and hail storms. I have very rarely in winter seen a shower-cloud of more than 10,000 feet in thickness, but in the summer season, of certain years, I have measured many which have vastly exceeded these dimensions. In the August of 1858, I watched a shower-cloud having almost perpendicular sides, whose base was about 1,000 feet above the summit of Mont Blanc, which was hidden by a sheet of snow falling upon it. The upper surface of this cloud I estimated as 15,700 feet above its base. As this cloud travelled northward, producing a thunderstorm (I believe without hail) in the valleys, I could discern no change in its proportions. In England, on August 13th, 1857, I approximately measured several hailstorm clouds, whose bases were about 3,000 feet above the earth's surface, and whose thickness was a little more than 25,000 feet. Even this thickness was considerably exceeded on September 3rd, 1867, and August 4th, 1878, while in the summer of 1872 there were numerous examples

of thunderclouds having a vertical thickness of more than 32,000 feet. Although the majority of these clouds of enormous dimensions produced heavy hail, there were others from which, so far as I could ascertain, only rain fell. Measurements of the thickness of clouds in tropical countries would probably give us even more surprising results. I consider that in the British Isles the average thickness of hail-clouds in winter is not quite one-half that of hail-clouds occurring in summer. The summits of shower-clouds from which heavy rain or hail is falling commonly attain the level of the *cirrus* in winter and in summer, but this level is much lower in the former than in the latter season. The domes, however, of those portentously thick shower-clouds which I have above alluded to can be seen to permeate the *cirri* and to overtop them by several thousand feet.

"Although disposed to agree in the main with Mr. Clayden's conclusions as to the mode in which the form of precipitation is modified, I would call his attention to the remarkable fact that all those shower-clouds in which the drops are large have a more or less cirriform summit, and that the freezing of the particles composing the summits of these clouds takes place simultaneously with the commencement of precipitation through their bases. I know of only two classes of exceptions to this law. The first occurs in our own islands and elsewhere, when, although the drops are large, the shower is extremely slight. Showers of soft hail especially occur not uncommonly in the rear of a cyclonic disturbance from well-formed and hard-edged *cumuli*, but these showers never become what we should call "sharp," unless at the same time the summit of the *cumulus* is combed out in more or less feathery lines of snow. The other exception occasionally occurs in the Equatorial Calms over the Atlantic, and probably (though of this I have no evidence) over the Pacific also. Large well-formed *cumuli* of threatening aspect, and which are described as resembling great sacks of water, hang almost motionless during the day, and are precipitated in violent showers about sunset. I am informed by keen observers that there is no cirrification whatever about the upper portion of these clouds, and the showers produced by them are also unaccompanied by electrical discharges.

"The method employed by Mr. Clayden is one that I have adopted for many years, and is certainly the most simple. Caution is necessary in its application, as I have no doubt Mr. Clayden has found, owing to the fact that in a majority of cases the summit of the shower-cloud, especially if of great altitude, is rarely perpendicular above the shower at the earth's surface, on account of the varying velocities and also directions of the air-currents at different altitudes. The method may be conveniently supplemented by others, such as synchronous observations carried on by two or more observers situated on base lines of sufficient length. This might most effectually be carried on by the use of a telephone, where available, but I have never been in a position to employ this method. I have, however, found it useful to take synchronous observations with other observers at stated moments of the day, when the state of the sky permitted. The two observers should take as accurate altazimuth observations as possible of the principal clouds in the sky at previously concerted moments. Immediately afterwards sketches of these clouds should be taken by each observer, a process which can, I think, most readily be effected by the use of soft chalks; or an assistant might take the sketches while the observer is employed upon the altazimuth. I obtained in the spring of 1882 some useful measurements of the altitude of *cirri*, which do not lend themselves readily to any other process of measurement, in conjunction with Mr. Glyde, having a base line extending from Kingssand, near Devonport, to Babbacombe, Torquay.

"On two small points I venture to differ slightly from Mr. Clayden. I have frequently observed the cloud-plane (a term which I prefer to cloud-line) to descend very considerably in a particular cloud when a heavy shower is first formed, and to ascend above the bases of the surrounding clouds when the shower is nearly spent.

"Secondly, although it seems improbable that hail is often formed by the passage of rain-drops through an intensely cold stratum of air, yet on the other hand, in the presence of the vigorous convection-currents in and around a *cumulus*, it would be unwarrantable to assume that the vertical distribution of temperature in the body of such a cloud bears much resemblance to the vertical distribution of temperatures in an atmosphere where no *cumulus* exists. Such an assumption is also in some degree negatived by actual observations taken in balloons."

Mr. ARCHIBALD remarked that some valuable observations of cloud heights and thicknesses had lately been made by MM. Ekholm and Hagström in Sweden with theodolites, the observers being connected by telephone. The formation of hail had always been a difficult question, but he did not see any thing unreasonable in the theory put forward by Mr. Clayden. Ferrel had worked at this question and had arrived at somewhat similar conclusions. Hailstones such as he (Mr. Archibald) had seen in India must have fallen through a great thickness of cloud to have attained so large a size. He took exception to the statement contained in the paper, that hailstorms are not frequent on tropical plains. This was certainly not true in the case of Eastern Bengal, as during his residence in that district they were by no means exceptional occurrences.

Mr. WHIPPLE thought that Mr. Clayden's method of measuring the thickness of clouds, although ingenious, was hardly a sufficiently reliable one on which to found important deductions, and he therefore expressed some doubt as to the values contained in the paper. He believed that clouds reached a greater height than Mr. Clayden represented. He referred to some observations made recently at the Harvard Observatory in support of this statement. He thought the rate of the formation of the clouds should have been taken into account by Mr. Clayden, as the process requiring to be gone through in order to arrive at an estimate of the thickness of the cloud observed occupied some time, or at any rate time sufficient for the cloud to alter considerably. With respect to Mr. Clayden's remarks as to vapour cooled below the freezing point not solidifying until coming into contact with some object, he had read of similar experience in the account of the voyage of the *Vega*.

Mr. C. HARDING said that the papers were good, but they contained figures which seemed to him somewhat doubtful. He thought that too much value had been attached to conclusions which were drawn from only three observations in the case of hail. He could not accept the statement that clouds were always saturated, as he had passed in a balloon through a cloud when there was as much as 5° difference between the dry and wet bulb thermometers. Mr. Glaisher's observations in his balloon ascents also clearly showed that clouds were not necessarily saturated, and that the idea of an uniform decrease of temperature with altitude was not correct, as the author seemed to imply.

Mr. W. H. DINES thought the one thing certain about the formation of rain was the one which had been pointed out by Sir John Herschel, namely, that it was not caused by the condensation of vapour upon the falling drop. There were certain laws relating to the latent heat of steam and water which numerous experiments had shown to be as fixed and invariable as the law of gravitation. Now assuming that a drop, commencing to fall as ice from any height, at a temperature of 0° F., and falling during any period of time, reaches the ground in the form of water at 70° F., and also that it receives no heat from the air during its fall, even in these circumstances, the most favourable to the condensation theory that can be conceived, it may be shown by strict mathematical reasoning based on these physical laws that the total condensation upon the drop cannot be as much as 50 per cent.

THE PRESIDENT (Mr. Ellis) said that whatever might be thought of Mr. Clayden's paper he had worked in an excellent spirit. He arranged a plan for carrying out a proposed object, made the necessary observations, and finally used his observations on which to form a theory.

ON THREE YEARS' WORK WITH THE 'CHRONO-BAROMETER AND CHRONO-THERMOMETER,' 1882-84. By WILLIAM FORD STANLEY, F.R.Met.Soc., F.G.S.

[Read February 17th, 1886.]

THE matter I wish to bring before the Society is, the work done in three years by two clocks, constructed to measure pressure and temperature cumulatively; one of which I term a "Chrono-barometer," and the other a "Chrono-thermo-

meter." I exhibited the models of these and read a paper in February 1877[1]. The construction of these clocks may be again briefly described.

The Chrono-barometer is a clock that counts the oscillations of a pendulum formed by a suspended barometer. The upper chamber of the pendulum is a cylinder of an inch or more in diameter. By change of atmospheric pressure the mercury in the pendulum is displaced from the bottom to the top and *vice versâ*. The rate of the clock is accelerated or retarded in proportion to the displacement of the mercury.

The Chrono-thermometer is a similar clock to the above, and the pendulum is also a barometer, but instead of the lower chamber being exposed to pressure the whole tube is enclosed in a second hermetically sealed tube containing air. Atmospheric pressure being thus removed, the expansion of the included air by heat alone forces the mercury up into the vacuum chamber, and alters the period of oscillation of the pendulum.

Besides the two clocks having glass pendulums, I have constructed two similar clocks with steel pendulums bored carefully to standard gauges, the records of which have been carried on contemporaneously with the models previously described.

These clocks record the number of beats in a given period, whether a day, a week, a month, or a year. The difference of the number of oscillations indicated by the dials in equal periods, indicates the difference of pressure or of temperature during the periods. Thus the clocks will record from 89,000 to 90,000 beats daily, and the difference in the number from day to day may be reduced to a known scale by comparison with the barometer or thermometer observed for the same period.

The Chrono-barometer with steel pendulum shows an acceleration of 949 beats per day for every inch the mercury rises. In like manner the Chrono-thermometer gives an acceleration of about 17·5 beats for 1° Fahr. per day. In the construction of another Chrono-thermometer it would be advisable to increase the acceleration by enlarging the capacity of the air chamber.

In constructing these instruments I endeavoured, for several years, to ascertain if a vacuum would remain perfect in a steel chamber, or if steel were slightly pervious to air. I am still uncertain on this point. One thing is, however, evident—the vacuum is not now so perfect in the Chrono-barometer as at first, but as this is also sometimes the case with glass barometers, I cannot state whether it arises from the slow escape of occluded air in the mercury or otherwise, although the mercury was thoroughly boiled. With regard to the Chrono-thermometer with steel pendulum, air has, undoubtedly, reached the vacuum chamber, and I will therefore only give the results derived from the glass Chrono-thermometer. The inclusion of air in the steel pendulum instrument proceeds very slowly, and I assume is proportional to the time. It might possibly be prevented by varnishing the steel thoroughly.

The readings of the instruments were taken simultaneously with the time indicated by a good watch, compared daily with a mean time astronomical clock. Personal error enters of course into the reading; but the error, as

[1] *Quarterly Journal*, Vol. II. p. 352.

regards these instruments, could not be cumulative, and would be as great in total amount for one day as for one year, so that it may be assumed constant, not interfering with the mean observations recorded.

The Chrono-barometers during the period of the observations here discussed were placed under the ordinary circumstances of a barometer in my house, and will, therefore, need no further particulars as to position. The Chrono-thermometers were placed under special conditions, which it is necessary to describe, as it will be evident that temperatures recorded by them will not agree with those taken by the ordinary method. This difference was intentional, as I considered these instruments especially adapted to register a particular temperature phenomenon which may be termed average "climatic temperature," as contrasted with the shade or sun temperature.

To insure the conditions stated above as nearly as my means permitted, I placed the Chrono-thermometers in leaden cases formed like obelisks, about four feet in height from the ground. The base of the obelisk being 16 ins. square, it diminished to 12 ins. square at three feet. Upon this was placed a moveable head about one foot cube, having a cottage roof; this fitted nearly air tight upon the lower part, and covered the works of the clock. The clocks were wound once every week through air-tight fittings, whilst a small glass pane, inserted in the head of each case, permitted the dial to be observed. As a protection to the works of the clocks from rust, I placed a box of quick lime in the lower part of each case, with a large coil of fine bright iron wire over the lime, so that any moisture in the air might be absorbed. With these precautions I found the clocks continued in perfect order. The cases were placed in the open air, in a fair position for obtaining a mean temperature of the air, on the southern side near the summit of a mound. Buildings and trees a few hundred feet distant shaded them, in early morning and evening, from the sun, so that although the midday temperature would be in excess of the mean, the morning and evening temperatures were in defect. After the leaden cases had been fixed a few months, they assumed, by oxidation, the usual well-known lead colour tint which remains unchangeable; and would, therefore, in this state absorb a uniform amount of heat from the sun and the air approximately under like atmospheric conditions.

For the comparison of the work of these instruments the following table gives the number of beats of the glass and steel pendulums of the Chrono-barometers for three years:—

	1882.	1883.	1884.
Glass Pendulum	33,755,669	33,670,130	33,658,133
Steel Pendulum	32,695,348	32,690,765	32,680,976

The year is taken at 365¼ days. There is some discrepancy in the comparative indications of the two clocks, but possibly not more than would naturally follow from the difference of construction of the two pendulums, and particularly from the imperfections in the bore of the glass one. The steel pendulum, by the relatively higher number it beats over the glass one for 1884, shows that steel maintains a vacuum quite as well as glass, and it may therefore be considered to be fairly correct.

The following table gives the number of beats made by the glass and steel pendulums of the Chrono-thermometers for three years :—

	1882.	1883.	1884.
Glass Pendulum	83,995,083	83,997,070	84,015,995
Steel Pendulum	82,695,848	82,690,765	82,680,976

It is here evident that the steel pendulum is losing its vacuum, and the value, if any, of its work can only be estimated by allowing a proportional loss to time. I therefore insert the work of the glass pendulum Chrono-thermometer only in Table II. which follows below.

Table I. gives the monthly diurnal mean of the Chrono-barometer with steel pendulum for three years, as well as the mean barometrical reading at 9 a.m.

TABLE I.—CHRONO-BAROMETER.

Month.	1882.		1883.		1884.	
	Pendulum.	Barometer.	Pendulum.	Barometer.	Pendulum.	Barometer.
	Beats.	Ins.	Beats.	Ins.	Beats.	Ins.
January ...	90,148	30·369	89,626	29·940	89,768	30·136
February ...	90,018	30·213	89,807	30·110	89,626	29·934
March	89,728	30·047	89,759	29·914	89,594	29·955
April	89,458	29·794	89,624	30·022	89,478	29·830
May	89,541	29·961	89,487	29·931	89,439	30·019
June	89,334	29·925	89,297	29·941	89,369	30·045
July	89,179	29·854	89,167	29·880	89,146	29·970
August	89,212	29·893	89,231	30·006	89,120	30·029
September...	89,309	29·862	89,183	29·869	89,278	30·022
October	89,384	29·829	89,465	29·990	89,555	30·085
November ...	89,428	29·684	89,518	29·549	89,760	30·187
December ...	89,461	29·672	89,877	30·171	89,586	29·937
Year	89,597	30·008	89,503	29·943	89,476	30·012

TABLE II.—CHRONO-THERMOMETER.

Month.	1882.		1883.		1884.	
	Pendulum.	Shade Temp.	Pendulum.	Shade Temp.	Pendulum.	Shade Temp.
	Beats.	°	Beats.	°	Beats.	°
January ...	92,682	39·5	92,716	40·1	92,789	43·1
February ...	92,768	40·8	92,785	41·7	92,767	41·1
March	92,948	45·3	92,644	35·4	92,895	43·7
April	93,051	49·1	93,048	47·2	92,956	46·5
May	93,300	55·7	93,251	54·0	93,330	56·1
June	93,370	57·5	93,532	60·5	93,479	58·3
July	93,516	60·4	93,503	61·6	93,651	64·8
August	93,121	59·8	93,589	61·9	93,734	66·1
September	93,574	54·7	93,326	56·7	93,470	59·9
October	93,063	50·8	93,058	50·6	93,285	49·0
November ...	92,795	42·8	92,798	42·8	92,752	41·5
December ...	92,687	39·4	92,679	39·6	92,698	40·6
Year.........	93,074	49·5	93,079	49·4	93,131	50·9

There appears a discrepancy in Table I. of the Chrono-barometer as compared with the barometer, equal to ·025 in. mean difference in 1882, compared

with 1884; this is no doubt largely due to the rough approximation the single diurnal reading of the barometer gives, this being subject to inevitable personal and instrumental errors.

Table II. gives the monthly diurnal mean of the Chrono-thermometer with the glass pendulum for three years, together with a thermometer reading as 9 a.m.; this being entirely a shade temperature, only exhibits a very rough accordance.

I regret that the pendulum with which the above observations were made was accidentally broken in removing it from the International Inventions Exhibition; it has, however, been repaired to nearly its original form. When broken I found considerable oxidation of the mercury at its surface, as is generally the case in glass barometer tubes.

[NOTE.—The glass pendulum clocks are now deposited in the Scienc and Art Museum for permanent exhibition, where they will remain as models for any one who may care to pursue the subject further. I have re-filled the steel pendulums, and intend to keep the clocks going with these in their former positions many years.]

DISCUSSION.

Mr. LECKY said that he had taken much interest in these pendulums of Mr. Stanley's, as they were really a new departure in meteorological instruments, and as the oscillations ran to very high numbers the results admitted of close investigation. In order to test their regularity of action, he had taken the year 1883, and by dividing the monthly average of oscillations by the average height of the barometer he found that the number of oscillations corresponding to one inch of mercury varied very slightly from month to month, the maxima being in November and March, and the minima in August and December; the differences he thought might be easily accounted for. In the thermo-pendulum these differences were much greater, being evidently caused by its unfavourable position. The figures he arrived at were as follows:—

1883.	Barometer.	Thermometer.
January	2994	2312
February	2983	2225
March	3001	2617
April.....................	2985	1971
May	2990	1727
June......................	2982	1546
July	2984	1518
August...................	2974	1512
September	2986	1646
October	2983	1839
November	3030	2168
December	2979	2340
Means	2989	1952

The figures represent an equivalent of 1° Fahr.

Mr. WHIPPLE inquired regarding the number of beats recorded by the 'chrono-thermometer,' whether the records agreed on days with the same mean temperature. He thought this instrument might be so constructed as to be made useful for recording the accumulated temperature in day degrees above and below 42°, on the plan adopted by the Meteorological Office.

Mr. STANLEY said that the clock must register the number of pendulum vibrations, and could not possibly go wrong in that respect, and in fact was more correct than any number of eye observations of temperature could be. He had no means of testing the accuracy of the pendulum vibrations in comparison with

thermometer readings, as no means had been tried to place a thermometer under like conditions, but as regards relative rates the chrono-thermometer, being a mechanical thing, must repeat its action under like surrounding conditions, that is, under the same temperature, as this is a factor that affects change only in its rate.

Mr. SYMONS suggested that the daily values might be compared with the Greenwich mean temperatures.

Mr. C. HARDING thought that a comparison with the results obtained by the Harmonic Analyser would test the working of Mr. Stanley's instruments.

Mr. CURTIS remarked that the daily mean obtained by the use of the harmonic analyser was practically the same as would be obtained from twenty-four hourly measurements of a barogram, such as might be found in a volume of *Greenwich Observations;* and therefore, he thought, a mean obtained from the latter ought to be fairly comparable with the mean pressure obtained by Mr. Stanley's arrangement.

The PRESIDENT (Mr. Ellis) said that the late Prof. Rankine had, some years ago, proposed an arrangement somewhat similar to Mr. Stanley's chrono-barometer, a description of which is contained in the *Philosophical Magazine* for 1883, Vol. 6, the title of the paper being "On a proposed barometric pendulum for the registration of the mean atmospheric pressure during long periods of time." His proposal was to attach a siphon-barometer to a *revolving* pendulum, but it is not known that it was carried into effect.

PROCEEDINGS AT THE MEETINGS OF THE SOCIETY.

JANUARY 20TH, 1886.

Annual General Meeting.

ROBERT H. SCOTT, M.A., F.R.S., President, in the Chair.

Mr. T. W. BAKER and Mr. C. H. COTTON were appointed Scrutineers of the Ballot for Officers and Council.

Dr. TRIPE read the Report of the Council and the Balance Sheet for the past year (p. 72).

It was proposed by the PRESIDENT, seconded by Dr. TRIPE, and resolved :—"That the Report of the Council be received and adopted and printed in the *Quarterly Journal* of the Society."

It was proposed by Mr. LAUGHTON, seconded by Mr. BEAUFORT, and resolved:—"That the best thanks of the Royal Meteorological Society be communicated to the Council of the Institution of Civil Engineers for having granted the Society free permission to hold its Meetings in the rooms of the Institution."

It was proposed by LIEUT.-COL. BROOKE, seconded by Mr. BREWIN, and resolved:—"That the thanks of the Society be given to the Officers and other Members of the Council for their services during the year."

It was proposed by Dr. MARCET, seconded by CAPTAIN TOYNBEE, and resolved :—"That the thanks of the Society be given to the Standing Committees and to the Auditors ; and that the Committees be requested to continue their duties till the next Council Meeting."

The PRESIDENT (Mr. Scott) then delivered his Address. (p. 65.)

It was proposed by Mr. ELLIS, seconded by Mr EATON, and resolved:—"That the thanks of the Society be given to the President for the ability and courtesy displayed by him in the Chair during the past year, and for his Address, and that he be requested to allow it to be printed in the *Quarterly Journal* of the Society."

The Scrutineers declared the following gentlemen to be the Officers and Council for the ensuing year, viz. :—

President.

William Ellis, F.R.A.S.

Vice-Presidents.

George Chatterton, M.A., M.Inst.C.E.
Edward Mawley, F.R.H.S.
George Mathews Whipple, B.Sc., F.R.A.S.
Charles Theodore Williams, M.A., M.D., F.R.C.P.

Treasurer.

Henry Perigal, F.R.A.S., F.R.M.S.

Trustees.

Hon. Francis Albert Rollo Russell, M.A.
Stephen William Silver, F.R.G.S.

Secretaries.

George James Symons, F.R.S.
John William Tripe, M.D., M.R.C.P.Ed.

Foreign Secretary.

Robert Henry Scott, M.A., F.R.S., F.G.S.

Council.

Edmund Douglas Archibald, M.A.
William Morris Beaufort, F.R.A.S., F.R.G.S.
Arthur Brewin.
Frederic William Cory, M.R.C.S.
Henry Storks Eaton, M.A.
Charles Harding.
Richard Inwards, F.R.A.S.
Baldwin Latham, M.Inst.C.E., F.G.S.
John Knox Laughton, M.A., F.R.G.S.
William Marcet, M.D., F.R.S., F.C.S.
Cuthbert Edgar Peek, M.A., F.R.A.S., F.R.G.S.
Capt. Henry Toynbee, F.R.A.S., F.R.G.S.

Mr. Scott having left the Chair, it was taken by the newly elected President, Mr. Ellis, who thanked the Fellows for the honour they had done him in electing him to that office.

February 17th, 1886.

Ordinary Meeting.

William Ellis, F.R.A.S., President, in the Chair.

George Buchanan, M.Inst.C.E., Keston Tower, Keston, Kent;
Capt. George Henry Leggett, Brisbane, Queensland;
Herbert Coupland Taylor, M.D., J.P., Todmorden Hall, Todmorden; and
James Tolson, Ormiston, Cleveland, near Brisbane, Queensland,
were balloted for and duly elected Fellows of the Society.

The following Papers were read, viz. :—

"General Remarks on the Naming of Clouds." By Capt. H. Toynbee, F.R.Met.Soc., F.R.A.S. (p. 99.)

"On the Thickness of Shower Clouds." By Arthur W. Clayden, M.A., F.G.S. (p. 102.)

"On the Formation of Rain, Hail and Snow." By Arthur W. Clayden, M.A., F.G.S. (p. 106.)

"On Three Years' Work with the 'Chrono-Barometer' and 'Chrono-Thermometer,' 1882-84." By William F. Stanley, F.R.Met.Soc., F.G.S. (p. 115,)

CORRESPONDENCE AND NOTES.

Formation of Ice upon Water considerably above the Freezing Point.

The Assistant-Secretary, Royal Meteorological Society.

My dear Sir,

Yesterday morning I had occasion to note a phenomenon which I have never seen alluded to in any books accessible to me.

There is a small well in my garden, the temperature of which I have for some years been in the habit of observing. It appears to be supplied by percolation of the water that has drained through the hill above, rather than by any actual spring. If emptied below its normal level it fills again at the uniform rate of ½ inch per hour. The surface of water is 3 feet square; and the normal depth is 1 foot 2 inches. Only about half the surface of the water is directly exposed to the air: the rest being covered over by a stone roof and soil thereupon. The surface of the water is 1 foot below the path which runs close by.

The water in the well thus situated has the local reputation of never having been known to freeze. Certainly it has never had ice upon it, since I have registered its temperature, until the present month.

On January 20th, 26th and 27th, 1880, the temperature of the water fell to 38°·7. This is the lowest yet recorded. The exceptionally low temperature of this month was due to the cold of December 1879; from which the water had had no time to recover when the January spell of cold weather set in.

In January 1881 (which was preceded by a warm December) the lowest reading was 39°·5, on the 22nd. The readings of the dry and wet bulb at the same hour were 19°·0 and 17°·5 respectively. (I call special attention to the fact that this was a very dry atmosphere for this station.) From January 13th to 16th the mean 9 a.m. reading was 22°·2: and the water was never below 41°·5. Similarly from January 18th to 22nd the 9 a.m. readings averaged 24°·2: but the water only fell below 40°·5 on the 22nd, and recovered to 41°·0 on the 23rd. On the 26th it fell to 39°·7.

On March 23rd, 1883, it fell to 40°·0.

These are the only occasions on which it has fallen to 40° or lower since December 1879.

Therefore, on Tuesday last, March 9th, I was much surprised to find the surface covered with an excessively thin film of ice: while the temperature at the bottom was 39°·0—a fall of 0°·5 in the twenty-four hours.

I did not think of making special observations at the time; but it occurred to me afterwards that it would be interesting to ascertain how far downwards from the surface the layer of chilled water extended.

Yesterday morning there was again this same thin film of ice. I therefore inserted the thermometer very carefully, so that the bulb was only just covered by the water. The bulb is a small one (the thermometer being the maximum of one of Casella's pair of "Travelling Thermometers," No. 108), so that the bottom of the bulb was, in this position, less than ¼ inch below the surface, while the neck was just on a level with the film of ice, with which the boxwood frame was in actual contact; and the bulb was not more than ⅛ inch out of contact. The temperature in this position was 38°·5. The temperature at the bottom was 39°·5,

I then took the thermometer out of the water, and when it had fallen to 33°·0 I re-inserted it, so that the bulb was half in and half out of the water, and thus was partly exposed to the temperature of the air, which at that time was 32°·5 dry-bulb, and 29°·7 wet-bulb. The temperature at once rose to 37°·7.

It was plain, therefore, that the under surface of the ice film was in actual contact with water at 38°·0, or possibly rather more.

I then broke the film, which melted and disappeared at once. In five seconds at most no ice was left.

What I wish to ask is—How is it that ice can exist at all in absolute contact with water at 38°, and with the temperature of the air above it at all events not below freezing-point? (On the 9th the temperature of the air was as high as 36°·5, but the wet-bulb was 31°·7.) Is it that the unusual dryness of the air this year, producing a very low dew-point on the surface of the water, renders it possible for a film of ice to be formed of absolutely infinitesimal thickness, the upper surface of which is continually being renewed as fast as the under surface is dissolved by the water at 38°?

In this case we have, as it seems to me, the nearest approach possible to a geometrical superficies—length and breadth, but with a practically inappreciable thickness.

In any case I think that my experiment raises some questions which are well worthy of systematic experiments under artificial cold.

Very truly yours,
P. H. Newnham.

Maker Vicarage, Devonport,
March 15th, 1886.

A Simple Snow-Gauge. By William F. Stanley, F.R.Met.Soc., F.G.S.

Every meteorologist knows the tedious, unpleasant, and uncertain process of collecting snow from a rain-gauge, but in the South of England, particularly where a considerable fall is exceptional, the average observer does not care to go to the expense of a costly apparatus. Mr. W. F. Stanley's snow-gauge is as simple as it is inexpensive. It consists of an ordinary tin saucepan, from which the handle of the lid has been removed, and a circular hole cut with a pair of cutting compasses exactly to correspond in diameter with the edge of the ordinary rain-gauge. By running a copper bit round the newly cut edge, so as to tin it, the gauge will be preserved from rust. To measure the fall the saucepan is taken indoors, set by the fire, and its contents gauged in

the ordinary way. A saucepan with a 5-inch disc cut out of the lid need only cost one shilling. As the saucepan gauge might be required to be taken indoors during a fall of snow, it is better to have two for winter use. This gauge would be more durable, of course, if made in copper; but this would be more expensive.

Note on Richard's Thermograph and the Results it yielded for 1885 at Geldeston, Beccles. By E. T. Dowson, F.R.Met.Soc.

This "Note" relates to results derived in 1885 from a thermograph by Richard, of Paris, made according to a design suggested by Mr. G. M. Whipple, F.R.A.S., for recording both dry and wet bulb temperatures on the same cylinder, one above

the other. The instrument, which worked "very satisfactorily" at Kew, is constructed briefly as follows, and is placed in a screen of the Royal Meteorological Society pattern, 15 ins. by 24 ins. by 20 ins. (inside), with the usual standard instruments.

Each thermometer consists of a very thin curved metal case (a Bourdon tube) about 2½ ins. long and 1¼ in. wide, containing alcohol, one end of the thermometer being a fixture and the other movable. As the alcohol expands or contracts with the changes of temperature it alters the form of the curve of the thermometer, making it flatter or otherwise. The movable end of the thermometer answers to these alterations, and communicates them, by means of a metal rod, to a lever carrying a pen which inks correspondingly on a graduated paper wound on a cylinder, 3½ ins. in diameter, containing a clock which turns it round once in seven days. With the exception of the thermometers the instrument is enclosed in a metal case. The wet-bulb thermometer is covered with muslin, and is kept moist by a water vessel below into which the muslin dips, and also by a capillary siphon from a second water vessel above. The two thermometers are placed side by side, but inasmuch as they are curved reversely, they are as far apart as circumstances permit.

Corrections have been applied for any error in starting the pen, and also for the time errors observed at 9 a.m. and 9 p.m., which are not constant, and in the dry-bulb sometimes amount to 40 minutes or more, while in the wet-bulb they sometimes exceed an hour; in addition to these the wet-bulb thermometer requires a correction of 10°, since its pen is fixed 10° below the dry-bulb to avoid contact. The tabulations of the dry and wet bulbs have been made throughout the year, and the maximum and minimum for each month obtained as given in the Table, but only the 9 a.m. readings of the wet-bulb for January and July have been tabulated.

COMPARISON OF RESULTS FROM A RICHARD THERMOGRAPH WITH STANDARD THERMOMETERS.

1885.	9 a.m.			9 p.m.			Maximum.			Minimum.		
	Thermograph.	Standard.	Diff. from Standard.	Thermograph.	Standard.	Diff. from Standard.	Thermograph.	Standard.	Diff. from Standard.	Thermograph.	Standard.	Diff. from Standard.
	°	°	°	°	°	°	°	°	°	°	°	°
January	35·6	35·7	−0·1	37·0	37·0	0·0	50·6	50·8	−0·2	23·4	21·9	+1·5
February	41·4	41·5	−0·1	42·7	42·8	−0·1	55·6	55·9	−0·3	31·5	30·8	+0·7
March ...	41·3	41·3	0·0	37·7	37·6	+0·1	56·0	55·6	+0·4	27·0	26·0	+1·0
April	49·6	49·4	+0·2	43·8	43·6	+0·2	71·9	71·9	0·0	27·5	26·0	+1·5
May	50·9	50·8	+0·1	46·4	46·4	0·0	74·5	74·0	+0·5	31·5	30·7	+0·8
June	60·6	60·4	+0·2	54·8	54·6	+0·2	82·0	81·0	+1·0	39·5	38·0	+1·5
July	63·5	63·5	0·0	58·0	58·2	−0·2	80·5	79·9	+0·6	41·0	40·5	+0·5
August ...	60·0	60·0	0·0	54·7	54·7	0·0	76·1	75·9	+0·2	39·2	38·3	+0·9
September	55·9	55·7	+0·2	53·4	53·2	+0·2	73·8	73·3	+0·5	33·9	31·8	+2·1
October ...	46·7	46·2	+0·5	46·1	45·6	+0·5	64·0	62·9	+1·1	35·6	34·1	+1·5
November	43·4	43·4	0·0	42·8	42·9	−0·1	58·1	57·9	+0·2	33·5	32·1	+1·4
December	37·7	37·3	+0·4	38·3	38·1	+0·2	50·4	49·7	+0·7	22·0	19·9	+2·1
Means ...	48·9	48·8	+0·1	46·3	46·2	+0·1	66·2	65·7	+0·5	32·2	30·8	+1·4

The Mean 9 a.m. Wet Thermometer Readings for Thermograph and Standard in January and July were respectively 35°·0 and 34°·8, and 58°·5 and 58°·1, showing a difference from Standard of +0°·2 and +0°·4.

ON THE INFLUENCE OF FORESTS ON THE CLIMATE OF SWEDEN.

A VALUABLE Report on this subject has been prepared by Dr. H. E. Hamberg, and printed as an appendix to the Report of the Forest Commissioners of Sweden for the year 1884. The observations were commenced in 1876, on the principles estab-

lished by Dr. Ebermayer in Bavaria, but Dr. Hamberg soon found that the mere comparison of the results obtained at the forest station with those yielded by its sister station in the open country was insufficient to bring out all the peculiarities of forest influence, and accordingly he added a third class of station, situated in a clearing in the forest itself (*öppen plats i skogen*). The various results of these observations are discussed in a very exhaustive manner, and we must refer those interested in the subject to the Report itself. The author's conclusions, however, are very interesting and are reproduced here in full.

"Our researches do not allow us to determine whether the presence of the forests on the whole contributes to increase or diminish the quantity of heat in the atmosphere, that is to say, to raise or lower its temperature. In fact we have been entirely unable to take in account either solar radiation or the radiation from the needles[1] and the points of the trees. Until we are able to ascertain the quantity of heat which escapes from these surfaces, and its relation to that escaping from other surfaces, it is quite impossible to determine with certainty the influence of the forest on such an important subject as the mean temperature, and must confine ourselves to approximate estimations. Among the various surfaces which are met with in Sweden the most important are assuredly water, bare ground or rock, soil covered by herbage, and finally forest. Neither the surface of the lakes and sea nor the bare soil of town streets have any resemblance to the forest: the climate of the latter bears no similarity to a maritime climate or a town climate. A forest may best be considered as an instance of vegetation on a gigantic scale, as is evident from the low temperature of the ground under the trees, and the freshness of the air in summer, especially in the evening and at night time, thus affording evidence of active radiation. In this case the forest would be a source of cold rather than of heat. But here we are simply dealing with suppositions.

"From this point of view a forest is distinguished from all the other surfaces we have mentioned, in that it extends into a stratum of air lying far above that in which man lives and carries on all of his occupations which depend on climate, such as agriculture, &c. It should follow from this that whether the annual result of the presence of a forest be an excess or a defect of heat, the one or the other should, thanks to the winds, be communicated to a greater mass of air, and be less sensible in the stratum close to the ground. The thermic properties of other surfaces are more immediately available in the lower stratum, and consequently, from the practical point of view, exert a greater influence on the temperature of the earth and of its immediate vicinity.

"If, then, we confine our consideration to that which from the practical point of view is perhaps the most important, the influence of forests on the state of temperature in the stratum in which man generally lives, in so far as this can be determined in the ordinary way by thermometers, I think that our reply for this country (Sweden) will be less uncertain, and it is as follows :—

"In the districts of our country which are open and are cultivated, during the annual interval of cultivation, a forest lowers the temperature of air and soil during evenings and clear nights, restricting the period of daily insolation and thereby checks vegetation.

"The other influences of forests on temperature are either so slight that they possess no practical importance, as *e.g.* the moderation of cold in winter, or else are of such a character that they elude the ordinary mode of observation, by thermometers. Among the effects of this nature we may mention the well-known fact that forests afford shelter against cold and violent winds, to vegetation which would suffer from these winds, or to objects whose temperature is higher than that of the environment, as for instance the human body. It is in this last respect that the Swedish saying is true, namely that 'the forest is the poor man's cloak.' In certain cases it may also yield protection against the cold air or fog, which on cold nights comes from districts in the vicinity which are visited by frost. The advantages on the score of temperature derivable from the forest may therefore be considered to resemble that obtainable from a wall, a palisade, a hedge, or any object of that nature.

"On the one hand a forest, where it is close by offers mechanical protection against cold and violent winds. On the contrary, it does injury either

[1] The Forests dealt with were entirely of pines and firs.

by retaining the solar heat required by crops, or by lowering the temperature of the soil during clear nights and thus favouring the development of hoar frosts. At a distance forests have no sensible influence on the climate of Sweden.

"If we wish to put these results to a practical application, it is impossible to say in general whether one should, or even could, clear the forest without injuring agriculture. But it appears that as regards the temperature, if we disregard the utility of forests in other directions, we might make extensive clearances without any prejudice to agriculture. It is certainly not a mistake to say that our best cultivated districts are the freest from wood, nor is it a mere chance that the harvests are, on the whole, more sure in the open country than in the forest. In the event of a bad harvest it is, as I well know, the wooded districts which have suffered most. At the same time I must at once admit that these provinces are also influenced by other powerful physical factors, possibly even more active than forests, such as an elevated situation, a bad soil, the presence of swamps, &c. But nevertheless it appears to me, after all that has been said in the preceding pages, that the forest has some bearing on the subject.

"At the present day, the words spoken 130 years ago by Pastor P. Högström, and at that time member of the Swedish Academy, are very generally applicable, inasmuch as it has been found that cultivation can to a great extent remove from a district its tendency to hoar-frost; this same result has frequently been obtained by draining or by clearing the forests, particularly those of deciduous timber, where the fogs, especially those which bring on frosts, appear to have their origin and their aliment. On the contrary, a pine forest is an excellent shelter against cold, especially when it can stand between the country and marshes or surrounding districts where the cold has its rise. If, however, the forest interferes with sunshine and with wind it should be cleared. It results, therefore, that while in some districts the clearing of a forest has been beneficial in averting hoar-frost, in others the result has been directly the opposite."

RECENT PUBLICATIONS.

American Meteorological Journal. A Monthly Review of Meteorology, Medical Climatology, and Geography. Vol. II., Nos. 9-11, January-March 1886. 8vo.

The principal articles are:—The Arago-Davy Actinometer, by W. Ferrel (5 pp.). This is the conclusion of an article on the black and bright bulb solar thermometers commenced in a previous No.—On the determination of the true air temperature (14 pp.). This is the translation of a paper by Dr. H. Wild from the *Zeitschrift für Meteorologie*, with interpolations by Mr. H. A. Hazen.—Electricity of Thunderclouds, by P. Morrill (7 pp.).—The Mountain Meteorological Stations of Europe, by A. L. Rotch (22 pp.). The author, who is the Proprietor of the Blue Hill Observatory, Readville, Massachusetts, visited Europe last summer to make himself acquainted with the methods, etc. in use at the various mountain observatories. He now gives an account of the observatories he visited, and in these Nos. describes the stations at the Brocken, Schneekoppe, Wendelstein, Hoch Obir, Sentis and Rigi.—An Experiment in Long Range Prediction, by H. H. Clayton (7 pp.).—A Winter Journey on the Northern Pacific Railroad, by M. W. Harrington (12 pp.).—Foreign Studies of Thunderstorms, by W. M. Davis (10 pp.).—Observations on the Sun-glow and related Phenomena, by G. H. Stone (6 pp.).

Annales du Bureau Central Météorologique de France, publiées par E. Mascart, Directeur. Année 1883. Parts III. and IV. 4to. 1885.

Part III. (335 pp. and 5 plates) is devoted entirely to Rainfall. The number of rainfall stations in France in 1883 was 1716. This Part gives the daily falls at about 920 stations, and is accompanied by seventeen charts, showing the monthly, quarterly, and yearly distribution of rainfall.

Part IV. is devoted to general Meteorology, and contains the following papers:—Observations Météorologiques faites dans les Postes et les Consulats françaises (58 pp.). The observations reported are from Trebizond and Samsoun, in Asiatic Turkey; Port Said and Ismailia, in Egypt; la Canée, in Crete; las Palmas; St. Denis, Réunion; Naos, &c.—Observations Météorologiques faites dans la Region du Haut Sénégal et le Bassin du Niger, par Dr. Laferrière (10 pp.).—Sur la Distribution des Pluies dans l'Afrique Méridionale, par V. Raulin (20 pp. and 2 plates).—Etudes sur la position des grands centres d'action de l'Atmosphère au printemps, mois de mars, par L. Teisserenc de Bort (26 pp. and 24 plates).

Annuaire de la Société Météorologique de France, March-May 1885, and January 1886. 4to.

Contains:—Schémas simplifiés des mouvements atmosphériques dans les differents régimes d'hiver, par A. Poincaré (14 pp.).—Comparaisons entre les observations qu'on peut faire dans des lieux voisins, mais dans des conditions différentes, par E. Renou (2 pp.).—Date moyenne des vendanges à Bourges, par M. Duchaussoy (2 pp.).—Récherches théoriques sur la distribution de la chaleur à la surface du globe, par A. Angot (11 pp.).—Appareil pour observer couramment la direction et la vitesse des nuages, par P. Garnier (2 pp.).—Sur l'emploi du néphoscope de M. Hildebrandsson, par M. Fineman (3 pp.).—Sur la méthode de mesurer les hauteurs et les mouvements des nuages, par N. Eckholm et K. L. Hogstrom (5 pp.).—Sur la distribution des pluies en Australie pendant la période 1871-1880, par V. Raulin (12 pp.).

Annuaire de l'Observatoire Royal de Bruxelles, par F. Folie, Directeur de l'Observatoire, 1886, 53me Année. 8vo. 1885. 314 pp.

M. A. Lancaster contributes a paper (75 pp.) giving fesults of meteorological observations made at Brussels during the fifty years 1833-1882. The present paper is devoted entirely to the temperature of the air. The mean monthly results are as follows:—

	Jan.	Feb.	Mar.	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Year.
Max.	40°·3	43°·5	48°·4	56°·8	64°·6	71°·2	73°·6	72°·1	66°·0	57°·4	47°·5	41°·9	56°·9
Min.	32·0	34·2	36·3	41·5	47·3	54·0	56·8	56·5	52·2	45·9	38·5	34·0	44·1
Mean.	36·1	38·8	42·4	49·2	55·9	62·6	65·2	64·3	59·1	51·6	43·0	37·9	50·5

The highest temperature observed during the fifty years was 95°·4 on July 19th, 1881, and the lowest was —4°·4 on January 25th, 1881.

A Plea for the Rainband and the Rainband vindicated. By J. Rand Capron, F.R.Met.Soc. 80 pp. and 5 plates. 8vo. 1886.

These two articles were originally published in Symons's *Monthly Meteorological Magazine*. As they had attained a considerable circulation they have been reprinted and are now issued together in one volume.

Bibliothèque Universelle, Archives des Sciences Physiques et Naturelles. Troisième Période. Tome XV. No. 1. January 1886. 8vo.

Contains:—Etude sur la température des eaux et sur les variations de la température du globe, par Dr. A. Woeikof (21 pp.).

Brief Sketch of the Meteorology of the Bombay Presidency in the year 1884-85. By F. Chambers, Meteorological Reporter for Western India. Foolscap folio. 1885.

The meteorology of the year was characterised by several well-marked deviations from the normal conditions of an average year. The monsoon rains were very late in setting in, and were consequently deficient in the early part of the year rainy season, but heavy rain falling later, either nearly made up the average yearly quantity or produced an excess in all districts, except the frequently drought-stricken tract in the east of the Deccan, where the fall was below the average until very late in the season. The irregularities in the rainfall distribution were accompanied by the usual barometric indications.

CIEL ET TERRE. Revue populaire d'Astronomie, de Météorologie et de Physique du Globe. Janvier-Mars 1886. 8vo.

Contains :—Coup d'œil sur l'histoire et les méthodes de la Météorologie, par Dr. W. von Bezold (7 pp.).—La hauteur des nuages (12 pp.).

ESSEX FIELD CLUB—SPECIAL MEMOIRS. Vol. 1. REPORT ON THE EAST ANGLIAN EARTHQUAKE OF APRIL 22ND, 1884. By RAPHAEL MELDOLA, F.C.S., and W. WHITE, F.E.S. 224 pp. Maps and other illustrations. 8vo. 1885.

This is a very full, careful and exhaustive Report on the severe earthquake which was felt all over the eastern part of England on the morning of April 22nd, 1884. The shock occurred between 9·17 and 9.18 a.m., and the main axis of damage had a general direction North-east to South-west, extending from Wivenhoe to Peldon, with maxima of intensity at those two places. The number of buildings damaged was between 1,200 and 1,300, including 20 churches and 11 chapels.

METEOROLOGISCHE ZEITSCHRIFT. Herausgegeben von der oesterreichischen Gesellschaft für Meteorologie und der deutschen meteorologischen Gesellschaft. Redigirt von Dr. J. HANN und Dr. W. KÖPPEN. Dritter Jahrgang 1886. January to March. 4to.

This is the commencement of the joint publication of the Austrian and German Meteorological Societies. These Nos. contain articles on the following subjects :—Klima an der Lenamündung, nach einjährigen Beobachtungen, von Dr. A. Woeikof (7 pp.). This is a discussion of the observations made at Sagastyr, at the mouth of the Lena, which was one of the Russian Polar Stations. The station is protected by hills from the coldest winds, and yet the air is more generally in motion than in the valleys in the interior, so that the cold is not nearly so intense. The weather is decidedly variable, cloud being most frequent in summer, as is usually the case where ice is melting.—Die auffallende Abenderscheinungen am Himmel im Juni und Juli 1885, von O. Jesse (19 pp.).—Die mittlere Bewegung der oberen Luftströme, von Dr. H. H. Hildebrandsson (5 pp.). The author's conclusions are (1) the mean direction of cirrus in Europe lies between South-west and North-west; (2) in winter it is more northerly than in summer; (3) this northern component is especially marked in Sweden and on the north coasts of the Mediterranean; and (4) the direction of this upper current agrees with that of the depression tracks.—Der Föhnsturm vom 15 und 16 Oktober, 1885, und seine Wirkungen im bayerischen Gebirge, von Dr. F. Erk (8 pp. and plate). This is an account of the storm described by Col. Ward (*see* p. 55).—Ueber Wellenbildungen in der jährlichen Periode der Luftemperatur, von A. Magelssen (7 pp.). This is an attempt to show that there are regular waves perceptible in the temperature curves for all stations, from which the author states that he can foresee the character of the seasons. The periods and the amplitudes of these waves are, however, subject to variations as yet unexplained, which render prophecy insecure.—Einfluss des Mondes auf die Meteorologischen Elemente nach den Beobachtungen zu Batavia, von J. Liznar (8 pp.).—Beiträge zur Kenntniss der Vertheilung des Luftdruckes auf der Erdoberfläche, von Dr. J. Hann (16 pp.). This is a discussion of the existing materials for pressure charts in unfrequented regions. Dr. Hann makes an appeal to England to discuss fully the records from the stations established by Sir H. James, and turned over in 1862 to the Army Medical Department. The paper gives means for the Arctic Regions, Eastern Asia, Australia, New Zealand, the West Indies, and the Levant.—Phänologische Studien, von Dr. H. Hoffmann (8 pp. and plate).—Karte der Aufblühzeit von *Syringa Vulgaris* in Europa, von Dr. E. Ihne (2 pp. and plate).

MONTHLY WEATHER REVIEW (General Weather Service of the United States). October-December 1885. Prepared by Lieut. H. H. C. DUNWOODY. 4to. 1885-86.

Referring to the use of the terms "cyclones," "areas of low pressure," "tornadoes," &c. it is stated that the following brief definitions have been recommended for general use in the *Review*:—" It is advised that the terms 'areas

of high pressure' and 'areas of low pressure' be used in publications describing the location of either feeble or decided minima or maxima of atmospheric pressure, but upon the occurrence of distinct cyclones, as defined below, the term 'cyclone' should be used in descriptions. A cyclone is a large, gyratory storm, generally from 500 to 1,000 miles, or more, in diameter, with a considerable area of low pressure in the interior. A tornado consists of a very small and violent gyration of air, generally much less than a mile in diameter, with a rapidly ascending current in the centre, and a low atmospheric pressure very near the centre, although there is generally too much violence of agitation for it to be observed, and it is specially marked by a characteristic funnel-shaped cloud with a progressive movement."

Professional Papers of the Signal Service.—Prepared under the direction of Major-General W. B. Hazen, Chief Signal Officer. 4to. 1885.

No. XVI. Tornado Studies for 1884, by Lieut. J. P. Finley. In addition to a brief history of the tornadoes occurring during the year 1884, this paper presents a series of charts showing the relation of tornado centres to areas of barometric minimum. The author gives the following conclusions as the result of his studies:—1. That there is a definite portion of an area of low pressure within which the conditions for the development of tornadoes is most favourable, and this is called the dangerous octant. 2. That there is a definite relation between the position of tornado regions and the region of high contrasts in temperature, the former lying to the south and east. 3. That there is a similar definite relation of position of tornado regions and the region of high contrasts in the dew-point, the former being, as before, to the south and east. 4. That the position of tornado regions is to the south and east of the region of high contrasts of cool Northerly and warm Southerly winds, a condition that appears to be dependent upon the preceding, and is of use when observations of temperature and dew-point are not accessible. 5. The relation of tornado regions to the movement of upper and lower clouds presents some interesting points for study, but, as yet, no decided results. 6. The study of the relation of tornado regions to the form of barometric depressions appears to show that tornadoes are more frequent when the major axes of the barometric troughs trend north and south or north-east and south-west, than when they trend east and west.—No. XVIII. Thermometer Exposure, by H. A. Hazen (32 pp.).

Repertorium für Meteorologie. Herausgegeben von den Kaiserlichen Akademie der Wissenschaften. Redigirt von Dr. H. Wild. Band IX. 4to. 1885.

Contains:—Ueber den jährlichen Gang der Temperatur-Anomalien in den europäischen Cyclonen, von P. Braunow (19 pp. and plate.)—Ueber die Zuverlässigkeit der Haarhygrometer auf meteorologischen Stationen in Russland, von R. Bergmann (30 pp.).—Die Vertheilung der Winde an den Küsten des Schwarzen und Asowschen Meeres, von J. Spindler (56 pp. and 6 plates).—Ueber kleine unregelmässige Barometer-Schwankungen, von A. Schönrock (10 pp. and plate).—Einfluss der Qualität und Aufstellung auf die Angaben der Regenmesser, von H. Wild (23 pp.).—Jahresbericht des physikalischen Central-Observatoriums für 1883 und 1884 von H. Wild (114 pp.).

Report of the International Polar Expedition to Point Barrow, Alaska. 4to. 1885. 695 pp.

Lieut. P. H. Ray, who commanded this expedition, was present at the Meeting of the Royal Meteorological Society on May 21st, 1884, and gave an account of the doings of the Expedition, which is printed in the *Quarterly Journal*, Vol. X. p. 262. The present Report is a most extensive and valuable one, and rendered more interesting by a number of coloured sketches. The work is arranged under the following divisions:—1. Orders and Instructions; 2. Narrative; 3. Ethnographical sketch of the natives of Port Barrow (including vocabulary and list of ethnological specimens collected); 4. Natural History; 5. Meteorology (including Aurora); 6. Magnetism; 7. Tides; and 8. Miscellaneous Observations.

REPORT OF THE METEOROLOGICAL COUNCIL TO THE ROYAL SOCIETY for the year ending 31st of March 1885. 8vo. 1886. 180 pp. and 12 plates.

In addition to the Report on the work done in the Meteorological Office during the year, this contains a number of Appendices, some of which give information on the following points:—Method followed in the collection of data from ships; Reports on the inspection of the stations in 1884; Method of dealing with telegraphic weather intelligence; Comparison of the Forecasts with the weather subsequently experienced in the different districts; and Methods followed in dealing with the land meteorology of the British Isles.

REPORT ON THE ADMINISTRATION OF THE METEOROLOGICAL DEPARTMENT OF THE GOVERNMENT OF INDIA in 1884-85. Folio. 102 pp.

Mr. Blanford prefaces his Report for the year with a general review of the progress achieved by the department during the five years 1880-85. He then gives his Report on the work done during the year, which is followed by the Reports of the Meteorological Reporters of the various Provinces.

SYMONS'S MONTHLY METEOROLOGICAL MAGAZINE. Nos. 240-242, January-March 1886. 8vo.

Contains:—Rainfall in South Africa, by W. B. Tripp (4 pp. and plate).—Thunderstorms in Russia (3 pp.).—Mr. Aitken on Dew (5 pp.).—Rainfall at Smyrna (2 pp.).—The frost of January 1886 (1 p.).—The great Snowstorm, February 28th to March 2nd (5 pp.).

THE ROSARIAN'S YEAR BOOK FOR 1886. Edited by the Rev. H. H. D'OMBRAIN. 8vo. 1886. (87 pp.)

This contains an article by Mr. E. Mawley on the Rose Weather of 1885 (14 pp.).

THE TRANSACTIONS OF THE SOUTH AFRICAN PHILOSOPHICAL SOCIETY. Vol. III. Part 2. 1883-85. 8vo. 1885.

Contains:—Irrigation on the Visch and Zah Rivers, Calvinia and Fraserburg Divisions, by Capt. J. A. Balfour (4 pp.).— On disturbances to thermometer readings from local causes, by A. Smith, M.A. (4 pp.).—Catalogue of printed books and papers relating to South Africa. Part II. Climate and Meteorology. Compiled by J. G. Gamble (46 pp.).

TRANSACTIONS OF THE HERTFORDSHIRE NATURAL HISTORY SOCIETY AND FIELD CLUB. Vol. III. Part 7. December 1885. 8vo.

Contains:—Meteorological Observations taken at Throcking, Herts, during the year 1884, by the Rev. C. W. Harvey (8 pp.).—Report on the Rainfall in Hertfordshire in 1884, by the Rev. C. W. Harvey (8 pp.).

TRANSACTIONS OF THE SANITARY INSTITUTE OF GREAT BRITAIN. Vol. VI. 1884-5. 8vo. 517 pp. 1885.

This volume is largely devoted to giving an account of the proceedings at the Congress held by the Sanitary Institute at Dublin from September 30th to October 4th, 1884. In Section III. a paper was read by Mr. G. J. Symons, F.R.S., on the Rainfall of Ireland (3 pp.). The broad general features of the rainfall are briefly these, viz. That most places within about 60 Irish miles (77 English miles) of the South or West coast have upwards of 40 inches of rain per annum, and that Central, East and North-East Ireland have between 30 and 40 inches, Dublin being almost, if not absolutely, the driest place in Ireland.

QUARTERLY JOURNAL

OF THE

ROYAL METEOROLOGICAL SOCIETY.

VOL. XII. | JULY 1886. | No. 59.

BRIEF HISTORICAL ACCOUNT OF THE BAROMETER. By WILLIAM ELLIS, F.R.A.S., of the Royal Observatory, Greenwich, PRESIDENT.

[Read March 17th, 1886.]

SOME general notions in regard to the weight and pressure of air seem to have been entertained in ancient times, but as in other questions of natural science, without any real advance in knowledge until greater attention was given to the experimental method of inquiry. At length the evident inadequacy of preconceived ideas to explain rationally the action of the common pump led to such further study of the subject that Torricelli, either by his own reasoning or by suggestions from others, was induced, in the year 1643, to make his celebrated experiment, when the barometer in its best form was at once created. Notwithstanding the time, thought, and labour that have been since expended, and the fertility of invention displayed in endeavour to improve, modify, and even supersede the old Torricelli tube, it still remains the most simple, as with our modern mechanical appliances it is also the most perfect form of barometer that we possess. Great as was the field of inquiry opened out by the discovery that the column of mercury was shorter in the anticipated proportion than that of water, it was not at the moment suspected that an instrument had at the same time been invented, destined in after years to play so important a part in meteorological inquiry; its unconscious discovery in this way being in strong contrast with the slow progress of its companion instrument, the thermometer, towards a satisfactory form.

Some little time indeed appears to have elapsed before it was even noticed that the height of the mercury in the tube was variable, or that the variations had any relation with changes in the weather. Then, as an old writer says, "the curious began to make machines in order to observe these changes, some employing mercury and some water."[1] But difficulties arose. Discordances, frequently of considerable amount, were found to exist in the height of the mercury in different tubes, discussion of the causes of which, as well as of the luminous appearance frequently observed in the vacuum portion of the tube, forms the subject of numerous communications to the older scientific memoirs, besides which there was the imperfectly understood action of temperature. The siphon form of instrument would appear to have been early contrived, though in general abandoned as diminishing the range of motion of the mercury in the tube, the first ideas in regard to improvement, for such reasons as have been mentioned, running rather in the direction of endeavour to enlarge the scale.

As regards a name for the new instrument, we read in the *Philosophical Transactions* for 1666, page 153, that "Modern Philosophers, to avoid Circumlocutions, call that Instrument, wherein a Cylinder of Quicksilver, of between 28 and 31 Inches in Altitude, is kept suspended after the manner of the Torricellian Experiment, a Barometer or Baroscope . . . . . to detect all the minute variations in the Pressure and weight of the Air. For the more curious and nice distinguishing of which small changes, Mr. Hooke in the Preface to his *Micrography* has described such an Instrument with a Wheel, contrived by himself, and, by these two last years' trials of it, constantly found most exact for that purpose." Hooke's instrument with a wheel and index is described, as mentioned, in his *Micrographia* published in 1665, as well as in the *Philosophical Transactions* of the following year. This early form of instrument is sufficiently well-known to require here no further description. It would appear from these accounts that one line with single pulley only was used, not two distinct lines and a double pulley, as in later times. For common use the wheel barometer has been much employed, and was indeed used by Luke Howard, but its vitality has probably been in great measure due to the circumstance that some elegance of appearance can be more readily given to this form of instrument: now it is probably run rather hard in its struggle for existence by the more modern and favourite aneroid.

In the *Philosophical Transactions* for 1666 there is further an account of a different kind of instrument, Boyle's "new kind of baroscope, which may be called statical," a balance, carrying at one end a hermetically sealed thin and comparatively light glass sphere, and at the other a metal counterpoise, the angular deviation being measured by an index traversing a divided arc. He adds that, "this instrument being accommodated with a light wheele and an index (such as have been applyed by the excellent Dr. Chr. Wren to open Weather glasses . . . .), may be made to shew much more minute variations, than otherwise." Many years after, in the year 1871, Heller published in

[1] *Traittez des Baromètres, Thermomètres, et Notiomètres.* Amsterdam, 1688, page 21.

the *Philosophical Magazine* an account of a "barometer without mercury," really a similar arrangement, a scale beam, to the ends of which were fixed two bodies nearly equal in weight but differing greatly in volume, a hollow sphere and a solid cylinder.

One of the first proposals, independently of that of Hooke, for increasing the scale of the barometer, was that which has been ascribed to Descartes, although carried into actual execution by Huyghens, and consisted of enlargement of the diameter of that portion of the tube about the upper end of the mercurial column, and the attachment of a supplementary tube extending upwards and containing water, the motion of the surface of which in the added tube magnified the variations of atmospheric pressure. This construction proving unsatisfactory, independently of its awkward proportions, Huyghens in 1672 proposed another, known as the double barometer, in which, adopting the siphon form, the portions of the longer and shorter branches about the two ends of the mercurial column were both enlarged, an open supplementary tube extending upwards from the shorter open branch being added. Resting on the mercury and rising to a certain height in the tube, a mixture of water and aquafortis was placed, by which again a magnified representation of the variations of atmospheric pressure was obtained. In the year 1690 De la Hire proposed to vary the Huyghens arrangement by adding, at the upper end of the supplementary tube, a third enlargement, and employing above the mercury, instead of one liquid, two that would not mix, a portion of the upper fluid remaining always in the upper enlargement: thus the varying position of the point of division of the two liquids indicated the variations of atmospheric pressure. The same form had, however, been previously invented by Hooke, who, having early found the action of his wheel barometer to be uncertain, had his thoughts, so long before as 1668, turned towards the contrivance of some other form of extended scale barometer. His double barometer, perfected in 1685, is described in detail in the *Philosophical Transactions* of the following year. He used in the same way two liquids, the variation of the point of division between which similarly magnified atmospheric changes.

In the *Traittez des Baromètres, Thermomètres, et Notiomètres*, to which reference has already once been made, an early form of portable barometer is described, one having a closed wood cistern, experience, as the author says, having shown that there was no necessity for openings in the cistern, the pores of the wood giving sufficient means of communication with the external air.

The diagonal barometer, said to have been contrived by Morland, is one in which the upper part of the upright tube is inclined considerably to the vertical, for the purpose of increasing the apparent range. Ancient instruments of this pattern were to be seen in 1876 in the Loan Collection of Scientific Apparatus at South Kensington, and some instruments of this pattern have been recently made in London. Morland is understood also to have contrived the original form of balance barometer, in which the tube suspended from one end of a beam or steelyard floated in a fixed cistern, the

other end of the beam indicating the barometric variations. This is a principle adopted in recent times in many patterns of recording instruments.

Derham, in the *Philosophical Transactions* for 1698, refers to the diagonal form of barometer as "a tube communicated to me by a friend which serveth for the more nice measuring the height of the mercury." He also describes a portable barometer in which the tube above the mercury about an inch from the top is pinched in to bridle the blow of the mercury against the top, the instrument being suspended on a tripod stand. Before this time it would appear that no means were employed for accurately indicating the precise height of the mercury. But Derham, in this year, 1698, proposed to use for this purpose a "fine finger," a rack connected with which moved a hand, traversing an attached circular dial divided into one hundred parts corresponding to hundredths of an inch. Also in the same year Gray proposed to leave the barometer tube free, and read off the height by an adaptation of a double microscope furnished with a micrometer. This was supported by, and could be moved up and down on, a separate vertical rod. The observer is directed to turn the screw which raises or lowers the microscope until he has brought the hair in the field of view "to touch as it were the surface of the mercury." The upright scale is divided into tenths of an inch, lesser parts being read from a horizontal divided circular dial. The arrangement is, in principle, that of the modern cathetometer.

The rectangular barometer in which the tube at the upper closed end is formed into a cistern, and the lower end extended as a narrow horizontal tube, with the object of increasing the range of motion, the principal aim in these times, is ascribed to J. Dominic Cassini and John Bernoulli.

Amontons in 1688 contrived a diminished form of barometer in which the pressure of the atmosphere was sustained by the mercury contained in a succession of two or more siphon tubes of lesser height, the lower portion of one siphon being carried by an intermediate tube to the upper portion of the next, the connecting portions containing air. Increasing the number of tubes permits proportionate decrease of their height, but the difficulties attending the accurate construction of the instrument were too great to render it of any practical use. A construction similar in principle has been ascribed to Fahrenheit. The ingenious and more elegant conical barometer of Amontons is described in his *Remarques et Expériences Physiques*, published in 1695. This instrument was designed for use at sea, and consists of a single tube closed above, open below, and of diameter increasing gradually downwards. Decrease of atmospheric pressure causes the mercury in the tube to fall, the spreading out of the mercury diminishing its vertical height and measuring the new pressure. Amontons points out defects to which the instrument is subject, but, as showing important barometric changes, and as being better adapted for transport, he considered it more suitable for use at sea than other forms. Desaguliers describes it as having been much used, especially at sea.[1] And Halley, in the *Philosophical Transactions* for 1720, referring to

[1] *Experimental Philosophy*, Vol. II.

barometers of the kind made by a Mr. Patrick, proposes that two such instruments, as nearly alike as possible, should be used in combination for measuring altitudes.

Hooke's marine barometer consisted of the use, in conjunction, of an air thermometer, on which pressure and temperature both acted, and a "sealed" thermometer affected by temperature alone, so that, by comparison, changes of pressure could be inferred—in principle the modern sympiesometer, as reinvented by Adie, and of which there are various forms. Halley in 1700 says that he used Hooke's instrument in his late southern voyage, and that "it never failed to prognostick and give early notice of all the bad weather we had." Amontons in 1705 proposed in principle a similar construction also for use at sea. And various modifications of the same principle have been suggested. One is described by Desaguliers in the *Philosophical Transactions* for 1724 under the title of "A new contrivance for taking levels," in which, to neutralize the effect of temperature, he proposed in using his instrument to place the principal part of it in water of a constant temperature. In these instruments the fluid used was some comparatively light liquid. But in the year 1823, Murray and Meikle separately made proposals for employing mercury. Another instrument of the same class, including instrumental compensation for temperature, is Calantariento's portable mercurial barometer. To which may be added that other recently proposed and more satisfactory type of instrument, in which a definite degree of compression is measured, the Boylean-Mariotte portable barometer, by Macneill.

Fahrenheit in 1724 remarks on the variation of the boiling point of water under different atmospheric pressures, the principle involved in the thermometrical barometer.

Returning awhile to the wheel barometer, Le Clerc, in 1744, constructed a modified form of this instrument. A straight barometer tube was hung by a chain to a pulley provided with the usual index and indicating dial. But rise or fall of the mercury in the tube did not actually turn the pulley, and to make an observation the tube itself had to be raised or lowered, by rack and pinion, until a fixed mark on the tube was brought to coincide with the surface of the mercury within it. This operation reset the index, which continued to occupy the same position until another reading was required. The same action of the pinion worked another rack carrying a short tube also dipping into the mercury, so that when one tube became raised the other was correspondingly depressed, whereby the constant level of the mercury in the cistern was to be maintained. The inventor called the instrument an equation barometer. But it is cumbersome in form, in this respect contrasting greatly with the elegant instruments constructed by Fitzgerald, and described by him in the *Philosophical Transactions* for 1761 and 1770. In the second and more elaborate of these two forms there are two pulleys, each having an index hand; one revolution of the lower pulley corresponding to a change of three inches of atmospheric pressure, and one revolution of the upper pulley to a change of one inch of pressure. The pivots of the lower pulley moved each between three friction wheels, those of the upper pulley rested on two

friction wheels. Each pulley was also double. The line from the float passed once round the outer lower pulley, then passed to the outer upper pulley; that from the counterpoise was wound in the contrary direction, but otherwise in a similar way round the inner lower and inner upper pulleys, so that when once adjusted the index hands could not be misplaced. The upper index hand, moving once round for one inch change of pressure, acted upon two other delicately balanced index hands, each carried on a separate circle concentric with the axis, both circles running on friction wheels. These additional hands were pushed backward or forward by the registering hand for record of extremes of pressure. The mechanical parts of both instruments were the work of the watchmaker Vulliamy, and appear to have been constructed with great care. The first form of instrument was exhibited to the Royal Society, and both are said to have worked well.

The construction of barometer in which, by means of a screw acting upon a leather below the cistern or upon a leather bag in place of cistern, the mercury could be forced up to fill the tube, and so render the instrument portable, appears to be first mentioned by Rowning in 1744, in his *Natural Philosophy*, being there spoken of apparently as an acknowledged form. Bourbon, in 1751, invented a similar construction, which was reported upon as being apparently similar to the English Sisson. A similar form is described by Desaguliers. Brisson, in 1755, constructed a barometer in which, when the instrument was placed vertical, the superfluous mercury in the cistern ran out of a small hole into a receptacle, thus ensuring a definite level. Other overflow cistern arrangements were proposed by Lavoisier in 1779, Austin in 1790, Power in 1877, and by Negretti and Zambra in 1886.

De Luc, about the middle of the last century, constructed with great care a siphon form of barometer, which he employed in mountain work to a considerable extent. The mercury was boiled in the tube. There were two scales, the divisions of one increasing from an intermediate point upwards, and of the other from the same point downwards, the sum of readings giving the observed height. The scales were apparently without index or vernier; they were divided to quarter lines and smaller parts estimated by eye. We find here a thermometer provided for the purpose of correcting the observed reading for the effect of temperature.[1]

Cavendish, in the *Philosophical Transactions* for 1776, gives an account of the meteorological instruments "used at the Royal Society's house." The barometer was of the cistern kind of 0·25 in. bore, and the area of the cistern about 120 times that of the bore. The mercury was not boiled in the tube, and the thermometer "within doors" was recorded in case it should be desired to correct the observations for the effect of temperature.

The form of barometer prepared in 1780 for use by the Meteorological Society of the Palatinate was a cistern barometer, the internal diameter of the tube being 2 lines and the diameter of the cistern 17 lines. The mercury was boiled, and the scale was read by a sliding vernier having index projecting

[1] *Recherches sur les modifications de l'atmosphère.* Vol. II.

in front of the tube. A thermometer was provided for correction of the observations for temperature.

Nairne and others are understood to have constructed marine barometers in the last century in which the tube below the scale was very much contracted. Blondeau contrived a special form of siphon barometer for use at sea, in the construction of which he employed iron in consequence of the liability of glass to fracture when exposed to the firing of cannon. In the modern so-called "gun" barometer, however, by packing the tube with some substance that will not transmit vibration, it is found possible to employ glass tubes even with the present more powerful artillery.

Cotte, in his *Mémoires sur la Météorologie*, gives an account of a portable barometer by our English Ramsden, which is of some interest. He speaks of having obtained the drawing and description of the instrument from a loose leaf in a dilapidated state which came into his possession in an accidental way, a circumstance curiously contrasting with the ready intercourse of modern times. In this barometer an index, standing across the front of the tube, was moved by rack and pinion until its lower edge, and that of a similar index placed behind and moving with it, could be seen in contact with the convex surface of the mercury, as a tangent to it, by which, as Cotte says, the height of the column of mercury could be measured with precision. This double index carried two verniers, one referring to a scale of English inches and tenths, the other to a scale of French inches and lines. There was also an attached thermometer graduated according to both Fahrenheit and Réaumur, with a supplementary scale showing the corresponding correction in hundredths of an inch, English, for reduction of the barometer reading in English inches to the standard temperature of 55° Fahrenheit. An index which could be set to the top of the thermometric column pointed out on this scale the correction required. Speaking of other of Ramsden's barometers, Cotte mentions a provision for adjustment of the mercury level of the cistern, consisting of an ivory float, a horizontal line on which, by screw action on the cistern, was to be adjusted to coincidence with other lines on adjacent fixed pieces of ivory. He describes also a form in which the frame of the instrument was cut away behind the upper portion of the tube, a ring encircling which was brought down until its lower edge just touched and shut out the light from the convex surface of the mercury. A precisely similar construction to this last he also ascribes to a French artist.

Hamilton, in 1791, proposed a portable barometer for measuring heights, in which the cistern was closed, the upper portion through which the tube passed being formed of cork. Englefield, in 1806, proposed another having a cistern of box-wood entirely closed up: he describes it as being sensitive and as comparing well with a Ramsden barometer. A similar arrangement of cistern entirely closed had been long before proposed in the Amsterdam work to which reference has been before made.

Gough, in 1807, applies to the lower widened branch of a siphon barometer an ivory piston moveable by means of a rod passing upwards, which was raised or lowered as necessary before taking an observation to bring the surface of

the mercury to the level of a line cut on the external surface of the glass corresponding to the zero of the scale. In an old barometer by Newman, now at the Royal Observatory, Greenwich, and formerly used in the astronomical department, this principle is more completely carried out by means of a double rack arrangement, by which the action of setting the barometer raises or depresses a plunger in the cistern corresponding in size to the internal diameter of the tube. The motions of the vernier and the plunger being in opposite directions, a constant level in the cistern is maintained. Wentworth Erck afterwards proposed a precisely similar arrangement.

We now come to another historic name. In the *Annales de Chimie* for 1816 there is description of a new portable barometer by Gay Lussac. He speaks of the then existing need for a barometer which should be easy of transport and which could at the same time be promptly observed, stating that, of the large number of portable barometers previously produced, few existed that had been approved or generally adopted. He adds that we must place in the first rank the cistern barometer of Fortin, as being distinguished by its exactness, excellent construction, and easy transport, only that it was a little heavy. A further remark would appear to indicate that this reference is to Fortin's arrangement of a fixed point to which the surface of the mercury in the cistern should be adjusted. Gay Lussac then describes his new form of barometer, which, adopting for lightness the siphon principle, he had indeed carried into execution some time previously. Experience, as he says, having shown that the new barometer had advantages, he in a modest way suggests that it might be worthy of a place amongst instruments of the kind. The lower part of the longer branch is much contracted, forming for a length of several inches a capillary tube, the shorter branch being closed, excepting that there is a small hole near its extremity from which the mercury will not escape except under great pressure. Both the columns of mercury are read. Gay Lussac adds most careful directions as to the manner in which the barometer should be practically constructed.

But it was afterwards in some instances found, and especially when the barometer in travelling occupied a horizontal position, that air would insinuate itself into the tube of the Gay Lussac form. On this account Bunten, of Paris, in the year 1824, placed within the lower part of the main tube another, tapering downwards and terminating in a small orifice, by which means access of air to the vacuum was entirely prevented. This improvement appears to be frequently, though by no means universally, ascribed to Gay Lussac himself, being known as the "pipette" or "air trap." But Arago and Humboldt, in testifying to the excellence of the addition in question, both speak of it as being due to Bunten, to whom, therefore, it would appear that the credit of the arrangement should be really assigned.

Excepting the preceding incidental mention of Fortin and a previous allusion in the *Annales de Chimie* for the year 1804, no more precise information concerning him has been met with. His elegant cistern arrangement, in which the mercury is raised until a fixed ivory point is seen just to touch [its] image reflected therein, would appear to have been in use before 1816, [but h]ow long before seems uncertain.

Playfair in 1816 recommended that barometer tubes for mountain work should be made of iron, proposing to fill them at the place of observation. Stevenson, in 1874, again proposed the use of iron for portable barometers, and describes a system of stopcocks for expeditiously clearing the vacuum portion of any remaining air.

The first mention of the practice of fixing a thermometer with its bulb in the barometer cistern, for ascertaining the proper temperature of the mercury, is found in a paper by Newman in the *Quarterly Journal of Science* for 1824.

Blackadder in 1825 proposed to arrange a number of barometers, each having a cistern of iron in which was a small orifice governed by an air-tight stopcock, so that, by clock action, communication between the cistern of each barometer and the external air might be cut off at successive hours, and thus give indications of atmospheric pressure during absence of an observer. Lamont with a similar object afterwards proposed to employ twelve separate barometers, having arrangement by which they should severally indicate the barometric pressure at definite times; but ultimately, in 1846, he adopted an arrangement in which one barometer was made to serve.

In the *Philosophical Transactions* for 1837, Baily describes the well-known flint-crown glass standard of the Royal Society, which consisted of two distinct tubes, one of flint and one of crown glass, dipping both into the one cistern. The scale, common to both tubes, was carried by a rod passing between them and terminating below in an agate point, which (carrying the rod and scale) was adjusted by rack and pinion to the surface of the mercury in the cistern. The diameter of the flint-glass tube was 0·594 in., that of the crown 0·658 in. At this epoch also were made the excellent Newman standard instruments, specimens of which are still in use at the Royal Observatory, Greenwich, and at the Kew Observatory. The diameter of the Greenwich tube is 0·565 in. A rod carries the scale above and terminates below in an ivory point, for adjustment to the surface of the mercury, as in the Royal Society instrument just described. The arrangement is the opposite of the more generally employed system of Fortin, in which the mercury is adjusted to the point which is fixed.

Howlett, in 1839, proposed to add a second tube filled with mercury to the height of 28 inches above the cistern level, the additional tube to be fixed to a float supported in the cistern, and to carry at its upper end a scale. It is assumed that no cistern adjustment would be required, and neglecting the slightly different lengths of mercury in the two tubes, that no correction for temperature would be necessary.

Davout in the *Comptes Rendus* for 1857 describes what he calls a repeating barometer, consisting of a graduated cylindrical glass tube placed in a vertical position and containing a small column of mercury, the extremities of the tube permitting of being opened or closed at pleasure. The mercury is at first in contact with the upper extremity, which is closed, the lower being open; closing it and opening the upper one, the mercury sinks to a small amount, then closing the upper end and opening the lower a further sinking occurs. This is one operation. Repeating the operations until the mercury

arrives at the lower extremity of the tube, the total fall of the mercury, with the number of operations performed, is described as giving indication of the variations of atmospheric pressure.

The contrivance of some satisfactory method of enlarging the barometric scale seems to have ever been a favourite project, and no less so in more modern times. M'Gwire, in 1791, proposed a floating mercurial barometer having a longer scale and which was also a recording instrument. In Howson's long range instrument the tube is fixed and of greater length than usual, there being attached to the bottom of its cistern a long light stalk rising upwards and occupying the central portion of the tube: the cistern, held in suspension, varies its position with the varying atmospheric pressure. Macneill's barometer is another of the long range kind, but here the cistern is fixed, in the mercury of which the tube is freely suspended. Both Howson and Macneill suggest that their instruments might be utilised for purposes of self-registration. Hicks has also proposed a barometer having extended scale consisting of a straight glass tube closed at the top and open at the bottom, the bore of the lower portion of the tube being larger than that of the upper portion. Another form by Hicks is one in which the upper portion of the tube is spiral shaped. And Guthrie connects the two branches of a siphon barometer by a horizontally placed spiral of smaller internal diameter, having an included small air bubble to indicate the barometric change.

In Vol. II. of Du Moncel's *Exposé des applications de l'électricité* there is described a contrivance for adjusting the mercury level in the cistern of a barometer by application of an electric current. In place of an ivory point a platinum point is used, the electric circuit being closed when the mercury comes into contact with the point, which rings an electric bell. On connecting the battery, should the bell begin to sound the cistern requires to be lowered until the sound just ceases, but should the bell be silent the cistern must be raised until the sound just commences. It is shown also that by adding above the mercurial column another platinum point, communication with which is made through the tube, the same principle may be applied also to measurement of the height of the column itself. In this case the cistern point is attached to a screw carrying above a divided circular counter, moving vertically against the engraved scale. The barometric column is first adjusted by the cistern screw, then the cistern point is adjusted by the screw carrying the circular counter, the reading of which, in combination with the scale reading, gives the complete barometric indication.

In regard to primary standards, reference may be made for a description of the great Kew standard to a paper by Mr. Welsh in the *Philosophical Transactions* for 1856, wherein is also described the cathetometer arrangement for reading the standard and barometers to be compared therewith. Of other standards mention may be made of the normal barometer and cathetometer of the Russian Central Physical Observatory, of which a description is to be found in the *Repertorium für Meteorologie*, Vol. III.

A well-known and convenient form of modern English instrument is the Kew Marine Barometer, constructed by P. Adie at the suggestion of the Kew Com-

mittee of the British Association, in order to meet the requirements of the Brussels Maritime Conference of 1853. In this instrument the cistern is of iron without adjustment, and closed, excepting at a small protected aperture, the tube below the scale being contracted and including also the pipette arrangement. The whole is contained in a brass frame, the divided scale being shortened to compensate for the varying level of the mercury in the cistern. For sea use the instrument is supported in gimbals. The gun barometer, already alluded to, is a modification of that just described. The fishery or sea coast barometer is one intended to be simple, durable, and sufficiently accurate for ordinary practical purposes. Barometers used at Russian meteorological stations are described in Wild's *Instruction für meteorologische Stationen* and in the volume of the *Repertorium* just quoted. That used in the United States Signal Service work appears to be of cistern form, having a small glass index to which by screw action the mercury is adjusted.

But the forms of modern mercurial barometers really group themselves generally into two divisions, the cistern form and the siphon form, and although there exists great variety in the manner of arranging details of construction, these scarcely require special notice. The cistern form is that principally used in England, but on the continent the siphon form appears to be employed also to a considerable extent. Reference may perhaps be here appropriately made to two small appliances in regard to cistern barometers, Daniell's platinum guard, a thin piece of platinum tube attached to the open end of the barometer tube, and considered by Daniell to prevent the infiltration of air; and Wallis's barometer adjunct, a small microscope capable of being attached to a barometer cistern, to facilitate adjustment of the ivory point.

Allusion has been made to the discordances observed in early times between the indications of different barometers, one principal cause of which would no doubt be the presence of air in the tubes. Apparently, however, it was not until somewhat before the middle of the last century that the practice of boiling the mercury for correction of this defect began to be adopted. Earlier writers speak of the application of heat to drive out air, but the first description of actual boiling that has been remarked is that given by Beighton in the *Philosophical Transactions* for 1738. Speaking of the method of Orme, a maker of diagonal barometers, he says, "The Quicksilver is all purified from its Dross and earthy Particles by Distillation; and when the Tube is filled by a Pound and a half, two, or three Pounds of Mercury, and all the Air got out by the Methods used in filling Tubes, then the remaining Air is got out by such an intense Heat of Fire as makes the Mercury boil, ... which curious as well as fatiguing Operation is continued for the Space of four Hours . . . . every part of the Mercury boiled for a long time." He goes on to say that barometers so prepared "are sensible of the most minute changes of the Air whatsoever. They foretell the Weather by a much longer Space of Time than others, as mostly 20 Hours, sometimes 36 or 48 Hours: Nay, before great Tempests, and such Rains as cause great Floods, for a much longer time before

they happen." De Luc, in his *Recherches sur les modifications de l'atmosphère*, Vol. I. p. 198, gives detailed instructions in regard to boiling the mercury in the tube, which appears about the middle of the last century to have been perfectly well understood, and since generally practised. In the Royal Society barometer, as existing in 1776, the mercury, as we have seen, is said not to have been boiled in the tube. For the barometers made, 1780, for the Meteorological Society of the Palatinate, the mercury was boiled.

The practice of attaching to barometer scales words indicating the kind of weather to be expected with different heights of the mercury appears to be one of comparative antiquity. At page 185 of the Amsterdam work, bearing date 1688, special directions are given in regard to the manner of placing them, and nine different distinctions of weather, corresponding to nine different heights of the mercury, are enumerated. They are in descending order, "grande sécheresse, tres-sec, beau confirmé, beau temps, changeant ou variable, pluie ou vent, grosse pluie & grand vent, orage, grande tempeste." Derham in the *Philosophical Transactions* for 1698 mentions weather plates, but says nothing about any words. Amontons in 1705 speaks of a barometer "monté à la manière d'Angleterre," which carried two little plates of copper marked with the different states of weather that might be expected to occur, as "beau temps, changeant, pluie, &c." The illustrations of Fitzgerald's wheel barometers 1761 and 1770 show six different distinctions of weather, whilst on the portable Ramsden barometer, previously described, and on other barometers of the same period, there are seven. In an old barometer by Reballio of Rotterdam, date unknown, ten such indications appear. Many modern barometers, however, carry only four, so that on the whole popular faith in the wording is probably weakening. The desire to supplant the old phrases by something better is not of recent origin. Changeux proposed a new wording for barometer scales having regard to different winds,[1] much in the same way that FitzRoy in more recent times endeavoured to introduce one that should better accord with actual fact.

In early times there was much uncertainty in regard to the action of temperature on the barometer owing to the complication produced by the frequent presence in the vacuum portion of more or less air. Amontons, in the *Mém. Acad. Roy. des Sciences* for 1704, appears to have first endeavoured to formulate a correction for temperature. He reduces to 50 by his thermometer, which represents apparently a low temperature, and he gives a table of corrections. De Luc determined the augmentation of the mercurial column due to heat by experimentally heating an apartment in winter, and concluded that an increase of heat which raised a thermometer from the freezing to the boiling point augmented the ordinary height of the mercurial column by six lines, and he adopted a temperature corresponding to one-eighth part of the distance between the freezing and boiling points, equivalent to 10° Réaumur or 54°·5 of Fahrenheit, as that to which barometer readings should be reduced, since it probably corresponded most nearly

[1] Cotte. *Mémoires sur la Météorologie*, Vol. I. p. 590, 1788.

with the average of all observations.[1] The Meteorological Society of the Palatinate in this seem to have followed De Luc.[2] Cavendish, in 1776, speaking of possible correction of the Royal Society observations, considers 50° Fahrenheit as that to which reduction would be made. In the Ramsden barometer the supplementary scale indicating the correction for temperature was arranged to give the reduction to 55° Fahrenheit. Cotte in 1788, however, speaks of reduction to the freezing point, and gives a table for the purpose.[3] Now the universal practice is to reduce to the natural zero of the freezing point.

Barometers have been constructed, as is well known, in which, instead of mercury, some liquid of less specific gravity has been employed. Water and other liquids appear to have been used in very early times, but coming down to the present century, Luke Howard in 1801 made a barometer of siphon form using linseed oil, and though he found the range of motion such as he expected, the discrepancy between the proportionate variation of the oil and quicksilver was continual and great: there were also other objections, and he gave the project up. In 1830 Daniell constructed the well-known water barometer of the Royal Society, describing all the operations with great detail in the *Philosophical Transactions* for 1832. It was filled by boiling distilled water, which was forced up the tube by the pressure of steam in the boiler. The tube being sealed, the boiler then became the cistern, in which the water was covered to the depth of half-an-inch with pure castor oil to cut off communication with the atmosphere. The barometer, however, became deteriorated, and in course of time was found to read 7 inches of the water scale too low. In 1844 Daniell was requested by the Royal Society to reboil and adjust the barometer, which was done; but whilst experiments with it were in progress occurred his lamented death. The instrument was afterwards removed to the Crystal Palace, Sydenham, where it was destroyed in the great fire which occurred there some twenty years ago. A successful form of water barometer appears, however, to have been contrived by Alfred Bird, of Birmingham, who gave an account of his instrument in the *Philosophical Magazine* for 1865. It was said to have been then in perfect action for six years. The water in the cistern was covered with olive oil. Mention should be made of the efforts in this direction of J. B. Jordan, who, not satisfied with water barometers, was induced to experiment with other liquids, and selected glycerine as seeming to answer for the purpose best. He covers the surface in the cistern with a shallow layer of petroleum oil. The record as given by a glycerine barometer constructed by Jordan appears daily in the *Times* newspaper. Glycerine has also been employed to form a compact long range barometer, by attaching to the short branch of a mercurial siphon barometer a narrow upright tube in which the glycerine is placed.

[1] *Recherches sur les modifications de l'atmosphère*, Vol. I. pp. 197 and 201.
[2] Traumüller. *Die Mannheimer meteorologische Gesellschaft.*
[3] *Mémoires sur la Météorologie*, Vol. I. p. 519.

In addition to mercurial and other barometers of the ordinary pattern, various kinds of floating barometers have been proposed; some in which the elasticity of air confined in a floating vessel causes it to rise or fall with the varying atmospheric pressure, as in those of Caswell 1704, and Cooper 1839; others in which a mercurial barometer is used to determine the floatation, as in those of Rowning 1733, Stevelly 1836, and Armellini 1867; in another, an American contrivance by Clum, 1865, and known as the Aëlloscope, a mercurial barometer in combination with a collection of air or gas chambers of considerable size is used. Several of these instruments, regarding their various principles of action, are interesting as contrivances, though not adapted to practical or scientific work, and we might enter into detailed description of some of them were it not that there are still more practical matters with which to deal.

Before speaking of metallic barometers it may be interesting to mention that Zaiher in 1758 proposed for use at sea a hollow cylinder void of air, of which the ends should be moveable, but kept apart by an internal spring, so that when the elastic force of the air augmented, the ends would approach, separating when it diminished. Of modern metallic barometers the principal are the ordinary aneroid, with its variations, and the Bourdon pattern. The question of forming a satisfactory instrument on the aneroid principle appears to have attracted other attention before the time of Vidi, the inventor of the aneroid, who himself seems to have arrived at a successful form only after the expenditure of considerable time and trouble. He is said to have produced an instrument as early as 1848, although it was not until some years afterwards that his instrument became generally known. It scarcely needs description. Improvements successively made have been the application of a temperature compensation bar, and the substitution of a laminated steel spring for the old form with spiral spring. Rush in 1851 added an altitude scale. Negretti and Zambra are understood to have first made aneroids of pocket size. Loseby, Goldschmid and others further modified them in the direction of doing away with the gearing work and substituting measurement by means of a micrometer. And Field, by an ingenious shift of the altitude scale, accommodates the instrument to different air temperatures for altitude work. Richard, Breguet, and others have adapted the aneroid, using one or more vacuum chambers, to register its indications on a revolving cylinder. The Bourdon form of metallic barometer consists of a thin elastic metal tube of elliptic section, in shape a portion of a circle, closed at its ends and exhausted of air. Increase or decrease of atmospheric pressure causes the ends to approach or recede, which motion by gearing work is communicated to an external index. Kohlrausch in 1874 caused a Bourdon ring to act on a small suspended mirror, in which by means of a telescope were seen by reflection the divisions of a fixed vertical scale. And by others the Bourdon ring has been made to work a pencil and give a continuous record.

Of other barometrical contrivances there are two of peculiar construction designed to indicate small changes of pressure; one is the differential baro-

meter of Wollaston, the other the differential microbarograph of Whitehouse. The former consists of a box composed of two equal divisions: a glass tube passes downwards from the bottom of one division, turns, and passes in at the bottom of the other. One division is open above, the other quite closed, excepting by a short horizontal pipe, projecting from one side. A little water being poured in, rises equally in each leg. Then oil is added on each side until it rises into the box, of course adding it so as to keep the water in each leg at the same height. Thus any additional pressure communicated through the horizontal pipe to the surface of the oil in the closed division of the box, acting through the glass tube, depresses the point of junction of the oil and water on one side, and raises it on the other. In the Whitehouse instrument the action depends on the flow and reflow of water between two hydraulic chambers, connected by a tube or siphon, one chamber being open to the atmosphere, the other closed but in pneumatic communication with an underground air chamber, so buried to ensure freedom from diurnal changes of temperature. The flow and reflow of water through the tube is made to move a tracing point. The instrument registers only minute variations of pressure. A capillary tube communicates between the air chamber and the atmosphere, whereby the equilibrium, disturbed by greater changes of pressure, is being constantly restored. The former instrument is for experimental use, the latter for showing small atmospheric variations.

In *Nature*, Vol. XXV., Joly, of Dublin, describes a scheme for ascertaining the reading of a distant mercurial barometer by a method which has possibly the merit of not having been before proposed. He carries two wires through the head of the barometer tube, one is continued downward into the mercury to a point below which the mercury never falls, the continuation of the other is a fine carbon thread carried also to the same point, and there joined to the wire. The outer ends of the wires pass to the recording station, an electric current sent from which traverses both wire and carbon in its passage. The carbon thread having a high resistance, the inventor considers that at a station four miles distant, involving eight miles of wire, and for a given diameter of copper wire and carbon thread, the variation of potential due to the rise and fall of the mercury in the barometer tube would be sufficiently marked to enable him to measure the barometric variations.

Reference should be made to Stanley's chrono-barometer exhibited before our Society in 1877, and again lately, having pendulum consisting of a mercurial barometer, the variations of which cause variation of rate. Thus the number of vibrations made during a given interval measure the mean atmospheric pressure during that interval. Prof. Rankine in 1853 proposed to attach a siphon barometer to a revolving clock pendulum, with a similar object. And a Mr. Hall exhibited some such contrivance in the Great Exhibition of 1851.

There is still a large subject remaining, that of recording instruments generally; one so extensive that in a paper of this kind little more than reference to some salient points in the history of the subject is possible. In the first

place, we read in Vol. I. of Cotte's *Mémoires sur la Météorologie* how, even in the last century, the importance of providing efficient recording apparatus was well understood. Attention then was naturally directed to the only one possible method of doing this, namely, by mechanical means. In connection with the application to barometric record we read of the names of Beaudoux, Courgeoles, Cumming, and Magellan, among others, as having either contrived or considered the question of recording instruments. The Beaudoux instrument, described by Cotte, consisted of a barometer of siphon form mounted on a semicircular beam, the equilibrium of which, on change of atmospheric pressure, became disturbed, and so gave motion to a recording pencil.

The records by these instruments appear to have been continuous, good in this respect, but, excepting perhaps the Beaudoux instrument, seemingly involving too much friction. Changeux, however, in 1780, introduced mechanism by which the recording pencil, instead of acting continuously, was left ordinarily free, and struck by a hammer at definite times. In a pamphlet dated 1781 he describes two forms of "barometrographs" of nearly similar character but both including this improvement, evidently considered to be an important one. The pencil in these instruments was carried by the float of a fixed siphon barometer, and made record on a circular disc revolving once in a week; the barometer was placed below the disc, the marker traversed its lower radius, and the lines on the disc indicating height of mercury formed concentric circles. An old instrument by Fontana apparently contained a similar arrangement for making record. One of Changeux's barometrographs was set up at Mannheim, and another at Munich. A suggestion made to substitute in the Munich instrument a rectangular plate for the circular disc and concentric circles was not carried out.[1] Changeux's plan of leaving the registering point free and striking or pressing it down at definite times is one that in more recent years has been frequently suggested and applied, not only for simple barographs, such as those of Kreil, Bryson, Lamont, Hardy and others, but also in several of the more elaborate meteorographs. Changeux himself had ideas of arranging some form of universal meteorograph.

The first contrivers of recording barometers in aiming at the production of a continuous record were so far right that they kept an excellent principle in view, one perhaps hardly sufficiently considered in the construction of modern recording instruments, so many of which, otherwise admirably arranged, give only an intermittent record, as once every ten or twenty minutes, in some cases less frequently. But since, in the old constructions, friction of the registering point interfered so much with its freedom of action, Changeux did wisely to give up the continuous record in order to secure one more accurate at definite intervals of time. The discovery however of photography, and the applications of electricity, opened out further opportunities and possibilities. The first person to propose that photography might be applied to record among other things the variations of the barometer was, so far as is known, T. B. Jordan, who would appear to have proceeded to make some

[1] Traumüller: *Die Mannheimer meteorologische Gesellschaft.*

practical experiment, and whose paper on the subject is contained in the Sixth Annual Report of the Royal Cornwall Polytechnic Society, that for 1838. Afterwards Brooke and Ronalds, working independently, carried this matter to a more practical issue, their papers on the subject of photographic registration appearing together in the same volume of the *Philosophical Transactions*, that for 1847. The system of Brooke in use at the Royal Observatory, Greenwich, and that founded on the system of Ronalds, in use at Kew and other observatories, are both found to work well, with the special advantage of giving a truly continuous record.

There is further the adaptation of electricity. Wheatstone, in the *British Association Report* for 1842, seems to have first suggested such an application, proposing that a platinum wire, governed by a clock, should at intervals make contact with the mercury in the tube of a barometer or other instrument, so creating an electric current which should both determine the record and the value of the element. In the volume of Du Moncel's work before quoted, a drawing is given of an apparatus by Wheatstone, said to have been made for the Kew Observatory, in which he applies this principle to the registration of the barometer and the dry and wet bulb thermometers. It has been since employed in the barographs included in the combined meteorographs of Salleron, Theorell, and Van Rysselberghe, the records being all intermittent.

So far photography and galvanism. We turn now again to barographs essentially mechanical in action, those in which the balance barometer is employed. It seems a little surprising that the first contrivers of barographs did not employ to a greater extent the balance principle, which, said to have been used by Morland two centuries ago, was afterwards illustrated experimentally by Desaguliers in his *Experimental Philosophy*, and, somewhat later, appears to have been also employed by Magellan.. At length, however, it was revived in a practical shape, in the year 1858, by Mr. Alfred King, of Liverpool, who, at the instigation of the late Mr. Hartnup, of the Liverpool Observatory, made a trial barometer on this principle, the performance of which proved so satisfactory that it led to the construction, in a following year, of the more elaborate barograph of the Liverpool Observatory. The principle was afterwards independently revived by Secchi in 1857, and has since come much into favour, having been employed in numerous barographs of later date. In some forms the cistern is fixed, and the tube carried by the beam which actuates the recording point; in others the tube is fixed, and the cistern attached to the beam. Of the former kind the barographs of King, Secchi, Wild, and Schreiber are examples, and of the latter kind those of Crova and Cecci. The barographs of Russell and Draper have moveable cisterns, but otherwise deviate from the ordinary balance form. In the instruments of King, Secchi, Cecci and Draper the records are continuous; in those of Wild, Russell, Crova and Schreiber they are intermittent. In some of these instruments the mechanical appliances for obtaining delicacy of action are much to be admired. Those of Secchi and Schreiber are portions of combined meteorographs.

There is yet another distinct type of barograph of which there are several

varieties, but all of which are continuously recording instruments. A small differential action originating either from a clock or from electric currents, in both cases controlled by the movement of the float in the lower branch of a siphon barometer, or, as in the Rung instrument, by disturbance of the equilibrium produced by the action of a similar barometer mounted on a counterpoised beam, is either in constant operation, or operates only when the height of the barometric column itself changes. By this means motion is communicated to a screw, or to a line passing over a pulley, in either case carrying a recording pencil. The original form of instrument is that of Regnard, of which detailed explanation is given in the attached list, and to which the instruments by Montigny, Hough, Redier (two forms), Gibbon and Rung are allied. When there is no change of atmospheric pressure going on, the recording pencil, in one variety of instrument, is in continual very slight oscillation: when the pressure changes the small oscillations in one direction preponderate, carrying forward the pencil: the Regnard and the two Redier instruments are of this character. In the Montigny, Hough, Gibbon and Rung instruments there is no action until the pressure changes, and the motion of the pencil is then by very small steps. The Regnard, Montigny, Hough and Gibbon instruments necessitate the use of a galvanic battery. The Hough instrument has in addition a type printing arrangement by which the record hourly or otherwise may be printed. The Gibbon instrument, excepting that there is no printing arrangement, appears to be almost precisely similar to that of Hough.

In terminating this necessarily brief review, I may remark that some incompleteness may result from the circumstance that I have been able to consult only such authorities as time and opportunity would allow. I have, however, endeavoured to make what has been given accurate, as far as it goes. A list is appended indicating where descriptions may be found of all forms of barometers and barometrical contrivances that have been met with in the preparation of this account.

Chronological List of known Forms of Barometers and of Inventions and Contrivances connected therewith.

In the following list a chronological arrangement has been attempted rather than an alphabetical one, for even if not always strictly accurate, such arrangement better enables a reader to grasp the historical relations of things.

For descriptions taken from any general work or catalogue, the date of such publication is, in default of better information, usually given, so that in such cases a later date than the true one may have occasionally been assigned. The list contains only such references as concern the instrument in its meteorological aspect, and does not enter into the question of its application to laboratory or other work:—

1643, Torricelli.—Date of the Torricellian Experiment.

In making this experiment Torricelli not only solved thereby the immediate vexed question of the weight of the atmosphere, but at the same

time unconsciously contrived the best form of that important instrument of meteorological and physical research, the barometer.

5, **Hooke.**—Wheel barometer. Hooke: Preface to his *Micrographia.*

A line from a float in the short branch of a siphon mercurial barometer passing over a pulley carrying index is attached on the other side to a counterpoise: the index moving over a circular dial points out the barometric variations thereon.

6, **Hooke.**—A new contrivance of wheel-barometer much more easy to be repared than that which is described in the Micrographia. *Phil. Trans.* Vol. I. p. 218.

Gives further account of the wheel barometer.

6, **Boyle.**—Of a new kind of baroscope, which may be called statical. *Phil. Trans.* Vol. I. p. 231.

A balance carrying at one end a thin and comparatively light glass sphere and at the other a metal counterpoise.

(?), **Morland.**—Steelyard or balance barometer. Rees: *Cyclopædia,* nder article Barometer.

A barometer tube suspended from the short arm of a steelyard floats in a fixed cistern: the other end of the arm indicates the barometric variations.

Morland is understood to have also contrived the diagonal form of barometer in which the upper part of the tube is inclined considerably to the vertical for increase of range of motion of the mercury.

Huyghens.—Extrait d'une lettre de Huyghens touchant une nouvelle nière de baromètre qu'il a inventée. *Mém. Acad. Roy. des Sciences,* l. X. p. 375.

Describes two forms having for object extension of the scale of variation: in one the tube about the top of the mercurial column is enlarged, and a supplementary tube added above containing water; in the other an upright supplementary tube is added to the short branch of a siphon barometer, the portions of the tube about both ends of the mercurial column being enlarged and a mixture of water and aquafortis placed in the supplementary tube.

Hooke.—Self-registering instrument. *Trans. Roy. Soc. Edinburgh,* l. XV. p. 508.

Bryson states that "Hooke was the first to propose a self-registered series of meteorological observations by an instrument which he quaintly called a weather-wiser, but no further notice is taken of this contrivance than a short description in one of his tracts bearing the date 5th Dec. 1678."

Hooke.—A description of an invention whereby the divisions of the rometer may be enlarged in any given proportions. *Phil. Trans.* Vol. I. p. 241.

A siphon mercurial barometer with added tube at short branch containing two liquids, the portions of the tube about the ends of the mercurial column and the upper end of the added tube being enlarged, the varying point of division of the two liquids indicating the variations of atmospheric pressure. As early as the year 1668 Hooke had bethought himself of putting some lighter liquid in a narrow added tube.

1688, Anon.—Portable barometer. *Traittez des Baromètres, Thermomètres et Notiomètres.* Amsterdam, 1688, p. 82.

Has cistern of wood completely closed, the pores of the wood being said to give sufficient means of communication with the atmosphere.

At page 135 of the same work instructions are given in regard to the placing of words on the barometer indicating weather to be expected with different heights of the mercury.

1688, Amontons.—Sur un nouveau baromètre. *Hist. Acad. Roy. des Sciences,* Vol. II. p. 23.

A series of shortened siphon tubes containing mercury connected each to the next by an intermediate tube containing air, the space above the mercury in the first siphon tube being a vacuum, and the last siphon tube being open to the atmosphere.

In the English translation of Deschanel's *Natural Philosophy,* Edit. of 1872, p. 160, a similar construction of instrument is ascribed to Fahrenheit.

1690, De la Hire.—Description d'un nouveau baromètre pour connoître exactement la pesanteur de l'air. *Mém. Acad. Roy. des Sciences,* 1708, p. 154.

A similar arrangement to that of Hooke of 1685. Another, almost identical, was proposed in the year 1881.

1695, Amontons.—Description d'un nouveau baromètre très simple et portatif à l'usage de la mer. Amontons: *Remarques et Expériences Physiques.* Paris, 1695, p. 121.

This is his conical mercurial barometer, a long taper tube of diameter increasing slightly downwards and open at the lower end.

1695, Quare.—Portable weather glass or barometer. *Specifications of Patents.*

"May be removed and carried to any place though turned upside down without spilling one drop of the quicksilver or letting any air into the tube, and that nevertheless the air shall have the same liberty to operate upon it as on those common ones now in use with respect to the weight of the atmosphere."

1698, Derham.—Portable barometer. *Phil. Trans.* Vol. XX. p. 2.

Describes a portable barometer having fixed cistern and tube pinched in near top to bridle blow of mercury against top; was supported on a tripod stand.

1698, Derham.—Contrivance to measure the height of the mercury in the barometer by a circle on one of the weather plates. *Phil. Trans.* Vol. XX. p. 45.

"A fine finger" pointing out height of mercury is attached to a rack which through a pinion gives indication by an index hand moving on a fixed circular dial. The inches are read from the scale and the parts of an inch from the dial, one revolution of the index corresponding to one inch vertical motion of the finger. Apparently the first attempt accurately to set and accurately to read a barometer; it would seem that previously the height of the mercury was simply estimated by means of the scale without either index or vernier.

1698, Gray.—About a way of measuring the height of the mercury in the barometer more exactly. *Phil. Trans.* Vol. XX. p. 176.

Adapts a microscope, carrying a horizontal hair or very fine wire in focus of eye-glass, and sliding up and down a separate rod, to read off height of

mercury in tube. The fine wire is set to the surface of the mercury and the height read off by an index moving on a fixed circular dial. The inches and tenths are read from the scale and the smaller parts from the dial, one revolution of the index corresponding to one tenth of an inch vertical motion of the microscope. A more accurate arrangement than the preceding, and in principle the modern cathetometer.

1700 (before), Hooke.—Marine barometer. *Phil. Trans.* Vol. XXII. p. 791.

Halley here speaks of Hooke's marine barometer as consisting of an air thermometer and a "sealed" thermometer used in conjunction. In principle the modern sympiesometer.

1704, Caswell.—Account of a new baroscope. *Phil. Trans.* Vol. XXIV. p. 1597.

The elasticity of air confined in a vessel open below and floating in water causes the vessel to rise or fall with varying atmospheric pressure. Said to be very sensitive.

1705, Amontons.—Baromètres sans mercure à l'usage de la mer. *Mém. Acad. Roy. des Sciences*, 1705, p. 49.

Special form of air thermometer used in conjunction with an ordinary thermometer. A modification of the Hooke marine barometer.

1705, Amontons.—Words on scale indicating weather. *Mém. Acad. Roy. des Sciences*, 1705, p. 229.

Amontons in a paper on barometers here speaks of one mounted in the English manner with little copper plates having different states of weather marked thereon.

1710, Bernoulli.—Le baromètre en équerre. De Luc: *Recherches sur les modifications de l'atmosphère.* Vol. I. p. 22.

A barometer in which the vertical tube having enlarged upper end terminates below in a narrow horizontal tube for increase of the scale of variation of the mercury. Had been previously proposed by J. Dominic Cassini.

1724, Desaguliers.—A new contrivance for taking levels. *Phil. Trans.* Vol. XXXIII. p. 165.

Alludes to a proposal by Gray to neutralize the effect of temperature on an air thermometer by placing the principal portion of it in sand, and so making it serve as a barometer for measurement of differences of level; then proposes as an improvement to substitute, instead of sand, water of a constant temperature.

1724, Fahrenheit.—Barometri novi descriptio. *Phil. Trans.* Vol. XXXIII. p. 179.

Indicates the principle of the thermometrical barometer.

1733, Rowning.—A description of a barometer wherein the scale of variation may be increased at pleasure. *Phil. Trans.* Vol. XXXVIII. p. 39.

A straight tube mercurial barometer carrying its cistern and having attached float, is buoyed in the fluid, as water, contained in another vessel: decrease of pressure causes the barometer to rise in the fluid, an attached index pointing out the barometric variations on a fixed graduated scale.

1738, Beighton.—The imperfections of the common barometers and the improvements made in them. *Phil. Trans.* Vol. XL. p. 248.

Describes Orme's process of boiling the mercury in the tube; the most early account of thorough boiling.

1744, Rowning.—Barometer with enlarged scale. Rowning: *Natural Philosophy*, Vol. I. part 2, p. 110.

An ordinary siphon barometer having added at the short branch a tube of smaller diameter turning downwards and containing water.

1744, Anon.—Portable barometer. Rowning: *Natural Philosophy*, Vol. I. part 2, p. 118.

Tube terminates in a leather bag enclosed in a little box, through bottom of which passes a screw by which the mercury may be forced to the top of the tube for facility of transport.

1744, Le Clerc.—Baromètre à cadran. Cotte: *Traité de Météorologie*, p. 148.

A modification of Hooke's wheel barometer: for description see the "Historical Account."

1751, Bourbon.—Baromètre portatif. *Hist. Acad. Roy. des Sciences*, 1751, p. 178.

Said to have been invented by Bourbon, but reported on as being apparently similar to the English Sisson. Its construction resembles also that of the portable barometer described in 1744 by Rowning. A similar construction is spoken of also by Desaguliers in his *Experimental Philosophy*, Vol. II.

1755, Brisson.—Baromètre portatif. *Hist. Acad. Roy. des Sciences*, 1755, p. 140.

Has overflow cistern arrangement for ensuring constant cistern level, also arrangement for filling the tube and confining the mercury therein for transport.

1755 (about), De Luc.—Baromètre portatif. De Luc: *Recherches sur les modifications de l'atmosphère*, Vol. II. p. 5.

The form of siphon barometer with which De Luc made so many of his observations in mountain work: it had two scales, one increasing from an intermediate point upwards, the other from the same point downwards, the reading of both branches being taken and added together: the scales were divided into inches, lines and quarter-lines, but had apparently neither index nor vernier: was provided with a thermometer for the purpose of correcting the observed reading for the effect of temperature: the whole instrument being mounted in a wooden case for carriage.

1758, Zaiher.—Baromètre marin. Cotte: *Mémoires sur la Météorologie*, Vol. I. p. 514.

Consisted of a hollow cylinder void of air, having moveable bases kept apart by an internal spring: on increase of atmospheric pressure the bases approach; on decrease they separate. Precursor of the aneroid.

1761, Fitzgerald.—A description of a new barometer. *Phil. Trans.* Vol. LII. p. 146.

An improved form of wheel barometer having double pulley, one for each thread, so that when once adjusted the index could not be misplaced;

had also two additional counterpoised hands moved by the index hand for record of maximum and minimum pressure. A carefully finished instrument, the moving parts turning on friction wheels.

1765, De Luc.—Thermometrical barometer. De Luc: *Recherches sur les modifications de l'atmosphère*, Vol. II. p. 283.

Describes in detail the construction of his apparatus: the bulb of the thermometer was immersed in the boiling water.

1765, Pyefinch and Magalhaens.—Barometer. *Specifications of Patents.*

"An instrument by which is shown the true effect of the weight of the atmosphere, with the variation which is caused by the heat and cold, and likewise the quantity of that variation."

1766, Cumming.—Clock barometer. Luke Howard: *The Climate of London*, Vol. I. 1818: Introduction, p. 18.

Says, "I have possessed for some years an eight-day astronomical clock, having a barometer connected with it, made in 1766, by Alexander Cumming, and which, on the decease of that excellent mechanic, his family allowed me to purchase. This curious instrument records, by means of a pencil supported on the quicksilver, and traversing a revolving scale, the movements of the barometer throughout the year; requiring for this purpose little more attention than the regular winding up of the clock."

1770, Fitzgerald.—An account of some improvements made in a new wheel barometer. *Phil. Trans.* Vol. LX. p. 74.

An improved form of the wheel barometer constructed by him in 1761, having an additional index and dial, one index making a complete revolution for three inches change of pressure, the other for one inch change of pressure, the latter acting on two other light counterpoised hands for indication of maximum and minimum. Moving parts all turning on friction wheels. For other particulars see the "Historical Account."

1776, Cavendish.—An account of the meteorological instruments used at the Royal Society's house. *Phil. Trans.* Vol. LXVI. p. 375.

Barometer was of cistern kind: area of cistern about 120 times that of the tube: mercury not boiled in the tube. Referring to the construction of thermometers, suggests that in determining the boiling point the bulb should be exposed only to steam.

1777, Beaudoux.—Barométrographe. Cotte: *Mémoires sur la Météorologie*, Vol. I. p. 567.

A barometer of siphon form is attached to a semicircular balance beam carrying a pencil: change of atmospheric pressure disturbing the equilibrium causes the pencil to mark on travelling paper: record continuous.

1779, Lavoisier.—Overflow cistern arrangement. Cotte: *Mémoires sur la Météorologie*, Vol. I. p. 516.

A barometer has its attached cistern immersed in an outer fixed cistern also containing mercury. When a reading is to be taken the barometer, by screw action above, is raised out of the fixed cistern, and the mercury flows out at a small hole in the attached cistern to this definite level.

1780, Changeux.—Météorographie ou Art d'observer d'une manière commode et utile les Phénomènes de l'Atmosphère. Contenant la description de deux Barométrographes ou Baromètres qui tiennent note par des

traces sensibles de leurs variations et des tems précis où elles arrivent; avec l'idée de plusieurs autres Instrumens Météorologiques, quelques Remarques sur les tentatives faites en ce genre et celles que l'on prépare, &c. *Pamphlet* bearing date 1781.

Describes in detail two barographs, generally similar. A float in the lower branch of a siphon barometer is made to raise and depress a pencil which moves over the lower radius of a revolving disc, making one revolution in a week: the pencil is free, excepting at the moment of being struck by clock action to give the record which is thus intermittent. Contains also other information in regard to recording instruments. [A construction of a similar kind is due to Fontana. See Loan Coll. Cat. Scientific Apparatus, p. 703.]

1780, The Meteorological Society of the Palatinate.—Barometer. Traumüller: *Die Mannheimer meteorologische Gesellschaft*, 1780-1795. *Pamphlet* bearing date 1885, p. 11.

The barometer of cistern form was read by a sliding vernier having index for setting projecting in front of the tube: mercury was boiled.

1781, Cavallo.—Description of a thermometrical barometer. *Phil. Trans.* Vol. LXXI. p. 524.

Describes his arrangement in which the bulb of the thermometer was immersed in the boiling water.

1781, Gaux.—Adjustment of the mercury level in cistern. Cotte: *Mémoires sur la Météorologie*, Vol. I. p. 515.

A siphon tube, having lower branch of large diameter, rests on a circular metal plate attached to the point of a screw by which the whole tube can be elevated or depressed. The end of the short branch projects into a small fixed bell-shaped vessel from the interior of which is suspended, hanging into the siphon tube, a bead of glass having a blackened point corresponding to the zero of the scale. By means of the screw the surface of the mercury is brought to coincide with the blackened point. Applied to an adjustable cistern this becomes, in principle, the Fortin arrangement.

1788, Anon.—Baromètre portatif. Cotte: *Mémoires sur la Météorologie*. Vol. I. p. 505.

Tube closed at top and bottom, with lateral opening near bottom: cistern fixed to tube, which is pinched in near upper end: sliding vernier.

1788, Ramsden.—Portable barometer. Cotte: *Mémoires sur la Météorologie*. Vol. I. pp. 507 to 510, and Vol. II. p. 71.

Describes barometers as constructed by Ramsden, some particulars in regard to which are given in the "Historical Account."

1788, Blondeau.—Baromètre marin. Cotte: *Mémoires sur la Météorologie*. Vol. I. p. 510.

A special form of siphon barometer constructed of iron, to withstand the firing of cannon.

1790, Austin.—Portable barometer. *Trans. Roy. Irish Academy*, Vol. IV. p. 99.

Overflow cistern arrangement. To avoid the necessity of applying a floating gauge the mercury is allowed to run off into a receptacle below,

so insuring a constant level. Mercury is forced back to again overflow when a reading is to be taken.

1791, M'Gwire.—Self-registering barometer. *Trans. Roy. Irish Academy*, Vol. IV. p. 141.

Barometer tube moving in guides is buoyed, and so floats in a fixed cistern: the tube carries tracing point for marking paper moved horizontally by clock work: record continuous.

1791, Hamilton.—A new kind of portable barometer for measuring heights. *Trans. Roy. Irish Academy*, Vol. V. p. 95.

Cistern entirely closed, having its upper surface about the tube formed of cork: barometer to be held in one hand and set for reading with the other: directs how to correct for capacity.

1796, Keith.—Description of a barometer which marks the rise and fall of the mercury from two different times of observation. *Trans. Roy. Soc. Edinburgh*, Vol. IV. p. 209.

A wire in connection with the float in the lower branch of a siphon barometer pushes up and down two small pieces of oiled silk, sliding easily on a fixed wire, for showing minimum and maximum: has enlarged upper chamber to make rise and fall of mercury in lower branch a maximum.

Date (?), Reballio.—Barometer combining siphon and long range barometer.

An old Dutch instrument in the possession of M. Pillischer of New Bond Street, London.

1801, Luke Howard.—Linseed oil barometer. See his *Climate of London*, Vol. I. 1818: Introduction, p. 14.

Constructed a siphon barometer, using linseed oil and lead pipe: was not found to be satisfactory.

1803, Maigne.—Baromètre portatif. *Annales de Chimie*, Vol. XLVII. p. 213.

Somewhat similar to forms already described.

1806, Englefield.—Simple and cheap portable barometer. *Nicholson's Journal*, Vol. XIV. 1806, p. 1.

Tube of small bore is fixed into a cylindrical box-wood cistern completely closed: unites lightness and ease of observation: weight 1¾ lb.: mercury said to take its level almost immediately: no difference of sensibility perceived as compared with a good Ramsden barometer.

1807, Gough.—Description of a correct chamber barometer. *Nicholson's Journal*, Vol. XVIII. 1807, p. 81.

In the lower widened branch of a siphon barometer, an ivory piston, moveable by means of a rod passing upwards, is raised or lowered as necessary, before taking an observation, to bring the surface of the mercury to the level of a line cut on external surface of the glass, corresponding to the zero of the scale. [Newman and others afterwards made the operation of setting a barometer act also on a plunger in the cistern by connecting the plunger to a rod having rack moved by the pinion used for setting.]

1810 (?), Fortin.—Adjustment of cistern level.

A Paris artist who is said to have contrived the much approved system in which by screw action from below the surface of the mercury in the cistern is brought just to touch a fixed ivory point representing the zero of the scale.

1811, L. O. C.—On the scale of the barometer. *Nicholson's Journal*, Vol. XXIX. 1811, p. 105.

Scale in strictness ought not to be full inches, but something less, owing to rise and fall of mercury of reservoir: places scales one at top and one at bottom, and reads both: suggests that instead of two scales the lower end of a single scale sliding in a groove might be adjusted to the surface of the mercury, when the height of the column could be instantly noted. [Making the scale terminate in an ivory point, this becomes the arrangement afterwards so excellently carried out by Newman in his standard barometers.]

1816, Playfair.—Mountain barometer. *Phil. Mag.* Vol. XLVII. 1816, p. 310.

Recommends iron tubes for barometrical observations in mountainous or remote countries, proposing that they should be filled at the place of observation.

1816, Kennedy.—Contrivance to render more portable. *Quar. Jour. of Science*, Vol. I. p. 295.

Introduces into the tube a small bell-shaped bulb of glass attached to a spiral spring and fastened to the top of the tube, to prevent concussion.

1816, Gay Lussac.—Description d'un nouveau baromètre portatif. *Annales de Chimie*, Vol. I. 1816, p. 113.

This is the well-known Gay Lussac siphon form, in which the lower part of the principal tube is contracted, and communication made with the external air only by a small hole near end of short branch, its extreme end being closed; both columns of mercury are read.

1817, Landriani.—A description of two barometers, one of which marks the maximum of elevation, the other that of depression, during its absence of the observer. *Quar. Jour. of Science*, Vol. III. p. 399.

No details: considers that by his instrument a greater degree of accuracy is reached than had been previously attained.

1817, F. J. H. Wollaston.—Description of a thermometrical barometer for measuring altitudes. *Phil. Trans.*, 1817, p. 183.

Describes his improved apparatus, and remarks that in boiling, the bulb should be exposed to steam only, as being steadier in its heat than water.

1818, Adie.—An improvement on the air barometer, which improved instrument is to be called a sympiesometer. *Specifications of Patents.*

Gas confined in a bulb and tube acts against oil or other fluid open to atmospheric pressure: has shifting barometric scale regulated by an attached thermometer. A revived form of Hooke's marine barometer.

1823, Murray.—Description of a barometer for measuring altitudes. *Phil. Mag.* Vol. LXI. 1823, p. 61.

Air confined in a closed cistern acts against mercury in a tube open to atmospheric pressure.

1823, Meikle.—On the construction of an air barometer. *Phil. Mag.*, Vol. LXII. 1823, p. 214.

Air confined in a tube terminating in a bulb acts through a closed cistern against mercury in another tube open to atmospheric pressure. Proposed as an improvement of the Murray arrangement.

1824, Bunten.—Addition of capillary tube. *Small pamphlet*, containing accounts of instruments by Bunten.

Inserts an additional contracted tapering tube, since known as the "pipette" or "air trap," in the lower part of the principal tube of a Gay Lussac siphon barometer. The pamphlet includes reports, from Arago and Humboldt amongst others, commending Bunten's arrangement.

1824, Newman.—On a mountain barometer constructed with an iron cistern. *Quar. Jour. of Science*, Vol. XVI. p. 277.

Substitutes cistern of iron in place of wood: fixes a thermometer with the bulb in cistern to obtain the proper temperature of the mercury: draws attention to the inaccuracy of the ordinary system of marking off barometer scales from a presumed standard without regarding the absolute height of the mercury or the relative proportions of the diameters of the tubes and cisterns.

1825, Blackadder.—On the construction of meteorological instruments, so as exactly to determine their indications during absence, at any given instant, or at successive intervals of time. *Trans. Roy. Soc. Edinburgh*, Vol. X. p. 337.

Barometer cistern of iron has small orifice governed by an air-tight stop cock, communication with atmosphere being cut off by a time-piece at any given instant: proposes to arrange a series of barometers to be thus acted on hourly, each in succession, during absence of observer.

1829, W. H. Wollaston.—On a differential barometer. *Phil. Trans.* 1829, p. 133.

For measuring small variations of pressure: for experimental use. Particulars will be found in the "Historical Account."

1830, Daniell.—On the water barometer erected in the Hall of the Royal Society. *Phil. Trans.* 1832, p. 539.

Contains a very full account of the construction of the barometer and of all operations in connection therewith. For a few particulars see the "Historical Account."

1831, Robinson.—Description of a mountain barometer the column of which is divisible into two portions for safer and more convenient transport. *Proc. Roy. Soc.* Vol. III. p. 40.

Of siphon form made to separate into two portions, one portion when out of use containing the mercury.

1834, Traill.—On a register barometer for indicating maxima and minima. *Proc. Roy. Soc. Edinburgh*, Vol, I. p. 57.

Consists of a diagonal and a rectangular barometer: piece of thick iron wire is introduced in upper part of former for register of maximum, and into horizontal arm of latter for register of minimum. Each index to be replaced by application of a magnet.

1836, Stevelly.—Description of a self-registering barometer. *Phil. Mag.* Vol. VIII. 1836, p. 67.

Tube fixed: cistern, connected to hydrometer floating in the fluid of a fixed vessel, by its rise and fall indicates variations of pressure which can be communicated to a recording pencil: scale may be made to bear any proportion to that of the ordinary barometer.

1837, Baily.—Description of a new barometer recently fitted up in the apartments of the Royal Society. *Phil. Trans.* 1837, p. 431.

Had two tubes, one of flint glass and one of crown glass, dipping into the same cistern: scale between the tubes, common to both, carried agate point below, for adjustment to the surface of the mercury in the cistern in the Newman manner.

1837, Woods.—Large standard barometer. *Quar. Jour. Met. Soc.* Vol. VII. p. 77.

A barometer made for the old Meteorological Society of London, "the proportion of the calibre of the tube to that of the cistern being as 1 to 50." A cumbersome and unscientific instrument, considering the date of its construction.

1838, Coggan.—Description of a self-registering barometer. *Proc. Roy. Soc.* Vol. IV. p. 72.

The wheel barometer principle, having float and pulley arranged to record at intervals on paper moved by clock work.

1838, T. B. Jordan.—On a new mode of registering the indications of meteorological instruments. *Sixth Annual Report (1838) of the Royal Cornwall Polytechnic Society*, p. 184.

First actual application of photography to the registration of barometric and other variations: suggests that by drawing opaque lines on the barometer tube its scale can be also photographed.

1839, Cooper.—Hydro-pneumatic baroscope. *Phil. Trans.* 1839, p. 425.

A vessel open below and floating in water contains a portion of air the dilatation and contraction of which, under variation of atmospheric pressure, causes the vessel to rise and fall. An instrument was constructed and the scale experimentally determined. Similar in principle to that of Caswell, 1704.

1839, Howlett.—Compensating barometer requiring no corrections either for zero or for temperature. *Proc. Roy. Soc.* Vol. IV. p. 133.

A second tube closed at lower end and filled with mercury to the height of 28 inches is placed by the side of the ordinary tube and supported by a float in the cistern: a scale rests on the mercury in its upper end: it is assumed that the difference of expansion of the two nearly equal lengths of mercury may be neglected. An arrangement almost identical with this was again proposed in the year 1886.

1840 (?), Daniell.—Platinum guard. Daniell: *Meteorological Essays*, 3rd Edit. Vol. II. p. 295.

Describes his platinum guard, a ring of platinum fixed to open end of tube in cistern to prevent infiltration of air.

1840, Newman.—Standard barometer.

Newman about this time constructed an excellent form of standard barometer, having tube of large diameter and fixed cistern: the scale was carried by a rod terminating below in an ivory point forming the zero, which, being adjusted by screw action to the surface of the mercury, adjusted also the scale.

1841, Kreil.—Barometrograph. *Magnetische und meteorologische Beobachtungen zu Prag.* 1841-1842.

Float in short branch of a siphon tube actuates a point which, struck by a hammer at intervals, gives indication on paper moved forward by a clock. A modification of the old Changeux principle.

1842, Beadman.—Improvements in the barometer. *Specifications of Patents.*

Proposes to weigh cistern and contents by a spring or balance: applies photography to the registration of barometric variations.

1842, Wheatstone.—On a new meteorological instrument. *British Association Report,* 1842: Notices and Abstracts, p. 9.

Suggests that a platinum wire should make contact with the mercury in the tube of a barometer or other meteorological instrument, so creating an electric current which should be utilized to record at intervals the instrumental variations.

1844, Bryson.—New self-registering barometer. *Trans. Roy. Soc. Edinburgh,* Vol. XV. p. 503.

The old Changeux principle in a still better form, a revolving cylinder being used for the record. An instrument was constructed and for some time used. Record intermittent.

1845, Hennessy.—On the application of photography to registering the thermometer and barometer. *Phil. Mag.* Vol. XXVII. 1845, p. 273.

Proposes that light passing through tube of barometer above the mercury shall be received on photographic paper drawn forward by clockwork: suggests the use of artificial light at night.

1846, Lamont.—Beschreibung der an der Münchener Sternwarte zu der Beobachtungen verwendeten neuen Instrumente und Apparate, 1851.

Contains account of recording barometer. The Bryson principle with variation in details. Record intermittent.

1847, Brooke.—On the automatic registration of magnetometers and other meteorological instruments by photography. *Phil. Trans.* 1847, p. 69.

This, the second of two papers, contains description of Brooke's application to barometer, in principle similar, though differing somewhat in details, from that actually adopted at the Royal Observatory, Greenwich, for description of which latter arrangement see account in the Introduction to the Magnetical and Meteorological Section of the several volumes of Greenwich Observations. The photographic record is governed by action from a float in the short branch of a siphon tube: record continuous.

1847, Ronalds.—On photographic self-registering meteorological and magnetical instruments. *Phil. Trans.* 1847, p. 111.

The arrangement for barometric record herein described may be regarded as that on which fundamentally the ordinary Kew pattern barograph is

based. See Report of the Meteorological Committee of the Royal Society, 1867. The top of the column of a cistern barometer is photographed, and the record is continuous.

1848, Vidi.—Aneroid barometer.

Produced the ordinary form of aneroid barometer in which a corrugated metal box exhausted of air is, by gearing work, made to actuate an index hand.

1850, Harris.—Improvements in barometers. *Specifications of Patents.*

A modification of the sympiesometer, employing mercury instead of oil.

1851, Rush.—An account of ascents in the Nassau and Victoria balloons with a description of Rush's registered dials. *Pamphlet,* dated 1851.

Adds to the aneroid an altitude scale.

1851, Dollond.—Atmospheric recorder. *Report of Jury on Phil. Insts.* 1851, p. 654.

Includes barometer of siphon form: again a modification of the Changeux principle: record intermittent.

1851, Hall.—Meteorological clock. *Report of Jury on Phil. Insts.* 1851, p. 658.

A barometer is kept vibrating by a clock, measuring by the number of vibrations made in a certain time the mean pressure of the air.

1851, Bursill.—Compensatory cistern barometer. *Report of Jury on Phil. Insts.* 1851, p. 658.

A self-acting contrivance for maintaining the mercury in the cistern always at the same level.

1851, Abraham.—Self-adjusting scale. *Report of Jury on Phil. Insts.* 1851, p. 658.

The scale, suspended from a pulley and counterpoised, has its lower end connected to a float in the short branch of a siphon barometer.

1851, Bourdon.—Metallic barometer. *Report of Jury on Phil. Insts.* 1851, p. 659.

Consists of a thin circular shaped elastic metal tube of elliptic section, closed at its ends and exhausted of air: on increase of atmospheric pressure the ends approach, and on decrease of pressure recede: this motion is communicated by gearing work to an index hand traversing a dial plate.

1851, Ericsson.—Alarm barometer. *Report of Jury on Phil. Insts.* 1851, p. 659.

Chiefly for use on ship board: cistern is attached to a balanced lever: when mercury sinks to a certain reading a gong is sounded: can be adjusted so that notice may be given when any required reading is reached.

1852, Negretti and Zambra.—Improvements in barometers. *Specifications of Patents.*

Short mercurial barometer with flexible bulb on which the atmospheric pressure acts. Also arrangement of small tubes at upper and lower ends

of an ordinary siphon tube, parallel thereto and communicating respectively therewith, placing in each small tube an index to show maximum and minimum pressure.

1853, Brown.—Improvements in barometers. *Specifications of Patents.*

Contrivances for reducing length of tube ; for increasing range of scale ; and for compensating sympiesometer form for temperature, thereby dispensing with the use of a thermometer.

1853, P. Adie.—Kew marine barometer. See *British Association Report, 1853 ;* and *Instructions in the Use of Meteorological Instruments,* published by the Meteorological Committee.

Cistern of iron having no adjustment: tube below scale contracted: shortened scale to compensate for variation of mercury level in cistern. A much used English instrument. The "gun" barometer, having its tube packed to check vibration, and used in the Royal Navy, is a modification of this form.

1853, Rankine.—Barometric pendulum for the registration of the mean atmospheric pressure during long periods of time. *Phil. Mag.* Vol. VI. 1853, p. 482.

Proposes to attach a siphon barometer to a revolving pendulum. Similar principle to that of Hall previously noticed.

1856, Wheatstone.—Enregistreur météorologique. Du Moncel: *Exposé des applications de l'électricité.* 2nd Edit. Vol. II. p. 370.

Said to have been made for the Kew Observatory: includes barometer, the indication being governed by electric current depending on contact made with the mercury in the short branch of a siphon tube: record intermittent.

1856, Liais.—Barométrographe. Du Moncel: *Exposé des applications de l'électricité.* 2nd Edit. Vol. II. p. 400.

The second form of an arrangement for recording by electric action (depending on contact made with the mercury in the short branch of a siphon tube) the maximum and minimum values of diurnal barometric pressure, with the times of their occurrence.

1856, Du Moncel and Masson.—Baromètre électrique. Du Moncel: *Exposé des applications de l'électricité.* 2nd Edit. Vol. II. p. 405.

Application of an electric current to (1) adjustment of the mercury level in the cistern, and (2) to complete measurement of the height of the column, leaving only the mere scale reading to be taken by eye examination. A slightly modified form of (2) has been constructed both by Salleron and Negretti & Zambra (see their respective catalogues).

1856, Welsh.—Account of the construction of a standard barometer, and description of the apparatus and processes employed in the verification of barometers at the Kew Observatory. *Phil. Trans.* Vol. CXLVI. p. 507.

Describes in detail the special method employed for filling the tube of the great standard, of above one inch internal diameter: also the cathetometer and manner of using it.

1857, Davout.—Mémoire sur un nouveau baromètre. *Comptes Rendus*, Vol. XLIV. p. 658.

Calls his instrument a repeating barometer: for an abstract of his description see the "Historical Account."

1857, Milne.—Barograph. Negretti and Zambra: *Treatise on Meteorological Instruments*, 1864, p. 82.

A construction somewhat similar to that of Kreil. Substituting a revolving cylinder for a moving rectangular board, this becomes a form of instrument, with intermittent record, since constructed by various makers, and known as the improved Milne.

1857, Thornthwaite.—Improvements in barometers. *Specifications of Patents.*

Makes barometer tube with flattened bore, employing enamel on one side: marks divisions upon flattened tube.

1857, Secchi.—Descrizione del Meteorografo dell' Osservatorio del Collegio Romano. *Estratto del Bulletino Meteorologico*, 1866.

Includes recording barometer, reviving the old Morland form of balance barometer: cistern fixed: tube of iron attached to beam: makes two separate and continuous records having different values of time scale: by the introduction of parallel motion arrangements the recording points are constrained to move in straight lines instead of in arcs of circles, as in many of the later contrived forms of barographs.

1857, Forbes.—Notice respecting Father Secchi's statical barometer, and on the origin of the cathetometer. *Proc. Roy. Soc. Edinburgh*, Vol. III. p. 480.

Consists of notes on various points in the history of these instruments.

1857, Regnard.—Barométrographe. Du Moncel: *Revue des applications de l'électricité* 1857 et 1858, p. 416.

A fixed barometer of siphon form has two turned up branches, one short, as usual, and one longer, extending also downwards: both are in communication, so that the mercury level is the same in each. A fixed platinum wire projects into the shorter branch, and a long plunger dips into the mercury of the longer branch. In connection with the fixed platinum point is a relay controlling two electric circuits. When the mercury is touching the platinum point, the relay current passes by one circuit; when the mercury is not touching the point, it passes by the other circuit; in the one case causing mechanism to elevate the plunger, and in the other case to depress it: the plunger is thus in continual very slight vertical oscillation, depressing or elevating the mercury to restore it to the level of the platinum point. On variation of atmospheric pressure the plunger becomes more elevated or more depressed on the whole, in order to maintain the mercury at this level, and its motions are communicated to a pencil marking on a revolving cylinder: record continuous: by diminishing the diameter of the plunger the scale of barometric variation becomes increased. [A new principle of action, of which the later contrivances of Montigny, Hough, Redier, Gibbon and Rung are all types.]

1857, Montigny.—Barométrographe. Du Moncel: *Revue des applications de l'électricité* 1857 et 1858, p. 420.

In this arrangement the mercury in the lower branch of a siphon tube is maintained at a constant absolute level by vertical shift of the whole

barometric tube. Two electric circuits closed, one by the rise, the other by the fall of a float, create currents which through mechanism act by a vertical screw, the one to depress, and the other to raise, the whole barometer until the mercury level is restored, when the contact becomes broken and the motion ceases. No action takes place unless the atmospheric pressure itself changes. The motion, which proceeds by very small steps, is communicated to a recording pencil.

1858, Hardy.—Barométrographe. Du Moncel: *Revue des applications de l'électricité* 1857 et 1858, p. 422.

In principle similar to the improved Milne, having double pulley instead of beam with unequal arms: record intermittent.

1859, Pursglove.—Improvements in barometers. *Specifications of Patents.*

Describes a mercurial barometer considered to be neither liable to oscillation nor affected by temperature.

1859, Newton.—Improvements in the construction of barometers. *Specifications of Patents.*

Atmospheric pressure acts on an elastic box containing liquid causing it to rise more or less in an attached closed tube freed of air.

1859, Bird.—Water barometer constructed and erected by Alfred Bird, of Birmingham. *Phil. Mag.* Vol. XXX. 1865, p. 349.

Was exhibited to the members of the British Association at their Birmingham meeting (1865), and said then to have been in perfect action for six years.

1860, Schultze.—Barograph. Schmid: *Lehrbuch der Meteorologie*, 1860, p. 321.

A modification of the old Changeux principle: record intermittent.

1860, Loseby.—The Maury barometer. *Printed explanatory sheet*, dated 1869. See also *Quar. Jour. Met. Soc.* Vol. V. p. 191.

An aneroid barometer constructed by Loseby at the instigation of Capt. Maury, who represented to him the necessity existing for a better form of the instrument, especially for mountain work. The ordinary gearing work is dispensed with, the motion of the vacuum box being multiplied by use of a fine micrometer screw which actuates an index hand: the divisions on the dial are contained in a spiral of several coils from the outside towards the centre: scale may be in feet, or in inches of barometric pressure.

1860, Newton.—Improvements in metallic barometers. *Specifications of Patents.*

Relates to improvements upon the Bourdon barometer: also applies thereto a band of paper moved by clockwork for registration of the barometrical variations.

1860, Salleron.—Description du météorographe du Depôt de la Marine. *Pamphlet* by Caspari, bearing date 1864.

Includes barometer: record is determined by electric contact made with mercury in short branch of siphon tube, and is intermittent.

1860, Tate.—New forms of thermo-barometers. *Phil. Mag.* Vol. XIX. 1860, p. 1.

Describes two improved but easily constructed and inexpensive forms, founded on the principle of the ordinary sympiesometer.

1861, Howson.—Long range barometer. *Specifications of Patents.* See also *Proc. British Met. Soc.* Vol. I. p. 81.

Tube fixed: light stalk from cistern rises axially up tube to a height of about 28 inches above fixed level of mercury in cistern: stalk, cistern and mercury therein are held in suspension by the pressure of the atmosphere, with the variations of which the cistern will rise or fall: a pencil attached to cistern may be made to record on travelling paper.

1861, Macneill.—Long range barometer. *Specifications of Patents.*

The last described construction reversed. Tube is freely suspended in the mercury of a fixed cistern by means of one or more attached floats and rises or falls according to the lesser or greater pressure of the atmosphere: a pencil rising and falling with the tube can mark on moving paper.

1861, Browning.—Improvements in barometers. *Specifications of Paten*[illegible]

Relates to indication of extremes since last setting by two hands yiel[illegible]ng without appreciable resistance to the index hand. [A principle car[illegible]ed out by Fitzgerald in 1761 and 1770.]

1861, Pitkin.—Improvements in aneroid barometers. *Specifications of Pate*[illegible]*ts.*

Jewels the axes of the working parts.

1862, Hicks.—Improvements in mercurial barometers. *Specifications of Patents.*

Makes the upper part of the tube of spiral form to obtain extended sc[illegible]le.

1862, Blackwell.—Improvements in barometers. *Specifications of Paten*[illegible]*s.*

Employs four or more aneroid chambers in combination; in anot[illegible]her instrument applies a micrometer arrangement for reading off observati[illegible]ons with increased accuracy.

1862, King.—Barograph. See *Report of the Astronomer to the Marine Co*[illegible]*m-mittee*: Liverpool: December, 1865.

Cistern fixed: floating and guided tube of iron hangs from pulley, on the other side of which is suspended a frame carrying a pencil wh[illegible]ich records continually on a revolving vertical cylinder. A trial balance ba[illegible]ro-meter was made as early as the year 1853, the action of which was conside[illegible]red to be so satisfactory that the more elaborate recording instrument w[illegible]as afterwards constructed, of which a very complete account is given in [illegible]the above mentioned Report.

1862, Wild.—Die selbstregistrirenden meteorologischen Instrumente [illegible]der Sternwarte in Bern. Carl: *Rep. für Exp. Physik.* Vol. II. p. 161.

Contains notice of Wild's first form of balance barometer: cistern fix[illegible]ed tube attached to beam: record intermittent.

1863, Mitchel.—Hermetic barometer. *Specifications of Patents.*

A flexible or elastic chamber containing liquid communicates by a t[illegible] with a rigid bulb enclosing air, the atmospheric pressure acts upon liquid through the medium of the flexible chamber.

1863, Jeannon.—Baromètre à air libre. *Les Mondes,* Vol. I. p. 581.

Special construction intended to indicate variations both of pressure [illegible] of temperature.

1863, Armellini.—Nouveau baromètre. *Les Mondes,* Vol. III. p. 99.

A peculiar form of floating barometer.

1864, Hicks.—Improved mercurial barometer. *Proc. Roy. Soc.* Vol. XIII. p. 169.

Has straight tube open at bottom without cistern, the bore of the upper portion of the tube being smaller than that of the lower, giving extended scale.

1864, Huntingdon.—Improvement in the scales of aneroid and mercurial barometers. *Specifications of Patents.*

Application of altitude scale [already done by others].

1865, Clum.—An improved instrument for indicating atmospheric changes. *Specifications of Patents.* Known as the Aëlloscope and described at length in a pamphlet bearing date 1866.

An arrangement consisting of a fixed mercurial tube and cistern, there being suspended in the tube a float having attached thereto several large external chambers containing air or gas. A complicated instrument.

1865, Cooke.—Improvements in aneroid barometers. *Specifications of Patents.*

Substitutes for the fine chain connecting the system of levers with the index hand a very thin tape-like band or fine wire of gold, platinum, or other ductile metal, by which a smoother motion is obtained.

1865, Hough.—Automatic Registering and Printing Barometer. *Annals of the Dudley Observatory*, Vol. II.

A disc, in communication with the float in the lower branch of a fixed siphon tube, completes an electric circuit above or below it according as the float is rising or falling, which through mechanism raises or depresses a vertical screw connected with a pencil by which a continuous record is obtained. The motion proceeds by very small steps. Type become also arranged by which in addition a record, hourly or otherwise, may be printed. [Very similar to the arrangement of Montigny as regards the registering portion of the apparatus.]

1866, Naudet.—Das holosterische Barometer. Carl: *Rep. für Exp. Physik.* Vol. III. p. 54.

Applies a thin laminated spring in place of the spiral spring of Vidi.

1866, Barret.—Description d'un nouveau baromètre différential. *Les Mondes*, Vol. XII. p. 448.

1867, Armellini.—Due nuovi barometri areometrici. *Estratto del Bulletino nautico e geografico di Roma*, Vol. IV.

A barometer tube having light attached metal sphere floats in a vessel containing glycerine: the lower portion of the vessel contains mercury forming cistern to the tube: rise and fall of tube indicate variations of pressure on an extended scale. [Reversing the positions of the tube and cistern the arrangement becomes that of Stevelly, 1836.]

1867, Breguet.—Barograph. Carl: *Rep. für Exp. Physik.* Vol. III. p. 330.

An aneroid barometer, employing four chambers in conjunction, is made by proper gearing to record on a revolving cylinder turned by clockwork: record continuous. Similar constructions have been arranged by Richard and others.

1867, Radau.—Mittheilungen über die auf der Pariser Ausstellung befindlichen physikalischen, mathematischen und astronomischen Instrumente und Apparate. Carl: *Rep. für Exp. Physik.* Vol. III. p. 281.

Contains much information relating to the history of recording barometers.

1869, Theorell.—Description d'un météorographe imprimeur. *Trans. of Roy. Acad. of Sciences*, Sweden, 1871.

Includes a barometer of siphon form: at intervals, by clock action, a steel point descends into short branch, and type become arranged in a definite position, regulated by electric action by the contact made between the point and the mercury; then the printing is effected. A band of paper sufficient to contain the record for three months is used: it rolls off one cylinder and as it comes from the machine is rolled on to another. There is no record other than the printed one.

1870 (?), Macneill.—Boylean-Mariotte barometer. Casella: *Catalogue of Meteorological Instruments.*

A compact and portable compression instrument, a definite degree of compression of air being measured by a column of mercury open to atmospheric pressure.

1870, Calantariento.—New portable mercurial barometer. *Phil. Mag.* Vol. XXXIX. 1870, p. 371.

Confined air acts against mercury in a tube open to atmospheric pressure: includes arrangement for compensating for changes of temperature.

1870, Goldschmid.—Ueber ein neues Aneroid-barometer, bestimmt zu barometrischen Höhenmessungen. Carl: *Rep. für Exp. Physik.* Vol. VI. p. 155.

No gearing work: the actual motion of the vacuum chamber is magnified in the motion of the long arm of a lever, which motion is measured by means of a micrometer.

In Weilemann's aneroid, noticed in the *Quar. Jour. Met. Soc.* Vol. V. 1879. p. 193, the increased motion produced by uniting several vacuum chambers is measured by means of a microscope containing a fiducial line and carried by a micrometer screw.

1870, Volpicelli.—Note sur un baromètre photographique. *Comptes Rendus.* Vol. LXX. p. 884.

In this arrangement a scale of millimètres traced on glass is photographed with the barometric variations upon the same paper.

1870, Wild.—Beschreibung des Normal-Barometers und Manometers des physikalischen Central-Observatoriums. *Rep. für Meteorologie*, Vol. III. p. 28.

Normal barometer with cathetometer arrangement.

1870, Wild.—Beschreibung unsers selbstregistrirenden Wagbarometers mit Temperatur-compensation. *Rep. für Meteorologie*, Vol. III. p. 181.

Wild's second and improved form of balance barometer: cistern fixed: tube attached to beam: record intermittent.

1871, Green.—U. S. Signal service barometer. *Nature*, Vol. IV. p. 412.

The barometer used by the Signal Office observers is said to be by Green, having cistern furnished with a small glass index to which the mercury is

adjusted by a screw working through bottom of instrument against the flexible bottom of cistern.

1871, Heller.—Barometer without mercury. *Phil. Mag.* Vol. XLI. 1871, p. 401.

A scale beam having at the ends two bodies nearly equal in weight but greatly differing in volume: fixes a mirror to the beam and observes its variations by means of a telescope and fixed vertical scale. [In principle the instrument is similar to the baroscope of Boyle.]

1871, Whitehouse.—Differential microbarograph for recording minute variations of atmospheric pressure. *Proc. Roy. Soc.* Vol. XIX. p. 491.

An instrument for measuring on a magnified scale small variations of atmospheric pressure. For some further particulars see the "Historical Account."

1872, Russell.—Self-registering electrical barograph. *Quar. Jour. Met. Soc.* Vol. I. p. 122.

Tube fixed: cistern floats in mercury: a reciprocating motion given by clockwork to a frame causes it to meet an arm, carried by and projecting from the cistern, at a different point according to the position of the cistern, thereby creating an electric current which compels a pen to rule ordinates so close together on paper on a revolving cylinder that they produce the appearance of a continuous curve.

1872, Stevenson.—Improved dial barometer. *Journal of the Scottish Met. Soc.* Vol. III. p. 289.

Proposes to employ two siphon barometers: the threads from the two floats to pass in opposite directions over two concentric rings or pulleys, the outer one being graduated, the inner one carrying an index: the length of the scale is thus doubled, independently of consideration of the diameters of the pulleys.

1873, Field.—Improved form of aneroid for determining heights, with a means of adjusting the altitude scale for various temperatures. *Quar. Jour. Met. Soc.* Vol. II. p. 10.

By shift of the altitude scale the instrument is accommodated to different air temperatures.

1873, George.—Mercurial barometer for the use of travellers, filled by the spiral cord method. *Quar. Jour. Met. Soc.* Vol. II. p. 29.

To be filled when required to be used: is graduated on glass tube and difference of mercury levels observed.

1873, Mendeleeff.—Differential barometer. Was exhibited at the London International Exhibition of 1873.

Appears to have been intended for philosophical work rather than meteorological.

1873, Van Rysselberghe.—Universal system of Meteorography. *Quar. Jour. Met. Soc.* Vol. II. p. 367.

Includes barometer: a dipping rod descends at intervals into the lower branch of a siphon tube and, on contact with the mercury, creates an electric current which causes a burin to draw a line whose length depends

on the height of the mercury: lines so drawn represent ordinates of the barometric curve: the cylinder is covered with a thin plate of copper coated with etching-varnish, and when the plate has received the inscriptions of the burin, it is taken off and plunged into aquafortis, and thus becomes an engraved plate.

1873, Wild.—Neues Heber-barometer. *Rep. für Meteorologie*, Vol. III. See also Carl: *Rep. für Exp. Physik*. Vol. XI. p. 389.

Describes a form of siphon barometer used at meteorological stations in Russia. Earlier forms of Russian station barometers are described in Wild's *Instruction für meteorologische Stationen*, 1869.

1873, J. B. Jordan.—On the construction of a glycerine barometer. *Proc. Roy. Soc.* Vol. XXX. p. 105.

Experimented with various fluids, and finally selected glycerine as the best for an extended scale barometer: has made several such instruments.

1874, Baumhauer.—Sur un météorographe universel destiné aux observatoires solitaires. *Extrait des Archives Néerlandaises*, Vol. IX.

Includes barometer in telegraphic communication with the recording station, and whose indication at that station is determined by electric contact: record intermittent.

1874, Crova.—Description d'un baromètre-balance enregistreur. *Mémoires de l'Académie des Sciences de Montpellier*, Vol. IX.

Tube fixed: cistern attached to counterpoised beam: record intermittent.

1874, Kohlrausch.—Ein Variations-barometer. *Poggendorff Annalen*, Vol. CL. p. 423.

An air exhausted Bourdon ring is made to act on a small suspended mirror: the barometric variations are observed by means of a telescope and fixed vertical scale.

1874, Stevenson.—Proposed portable iron barometer. *Journal of the Scottish Met. Soc.* Vol. IV. p. 265.

Has system of stopcocks for rapidly clearing air from vacuum portion.

1875, Redier.—New barograph. *Quar. Jour. Met. Soc.* Vol. II. p. 412.

An entirely mechanical barograph: a differential clock train causes a siphon barometer, by action from its float, to be kept in continual very slight vertical oscillation: when the atmospheric pressure is changing the motion in one direction preponderates, and actuates a pencil: record continuous.

1875, Power.—Proposed modification of the mechanism at present in use for reading barometers. *Quar. Jour. Met. Soc.* Vol. II. p. 487.

Fixes the vernier against a divided circle carried by the milled head used in setting the instrument, giving an enlarged scale.

1876, Tonnelot.—Form of French station barometer. *Loan Coll. Cat. of Scientific Apparatus*, p. 676.

Has cistern of large diameter to diminish capacity error.

1876, Gloukhoff.—Russian cistern barometer. *Loan Coll. Cat. of Scientific Apparatus*, p. 679.

The mercury is forced at each observation into an open space, and the lower end of the scale adjusted thereto.

1876, Hicks.—Patent flexible mountain barometer. *Loan Coll. Cat. of Scientific Apparatus*, p. 680.

Atmospheric pressure acts upon a flat bulb of flexible glass containing mercury: is exhausted of air and hermetically sealed.

1876, Krueger.—Compensated barometer. *Loan. Coll. Cat. of Scientific Apparatus*, p. 681.

The upper part of the tube is enlarged and air introduced, with the object of compensating for the effect of temperature.

1876, Muller.—Self-registering and signalling vessel barometer. *Loan Coll. Cat. of Scientific Apparatus*, p. 704.

Said to be new both as a whole and in its details: has uninterrupted automatic adjustment which by electric action makes all changes in the atmospheric pressure, even the smallest oscillations, audible: is also a recording instrument.

1876, Greiner and Geissler.—Barograph. *Loan Coll. Cat. of Scientific Apparatus*, p. 712.

Balance barometer: said to be used at all the normal observing stations on the German coast.

1876, Abercromby.—An improvement in aneroid barometers. *Quar. Jour. Met. Soc.* Vol. III. p. 87.

Jewels the ends of the arbor of the index hand, and makes the hand work underneath the cap.

1876, Festing.—On a new form of meteorograph. *Pamphlet* dated 1876.

Includes barometer of siphon form, float in which is connected with one end of a balance beam, the other end of which governs a marking point: record intermittent.

1876, Olland.—Le télémétéorographe. *Extrait des Archives Néerlandaises.* Vol. XIV.

Arranged to register at a distance. Includes barometer of balance form: tube fixed: cistern attached to beam: indication at recording station (in telegraphic communication with instrument station) is determined by electric contact which a moving arm makes with an arm in connection with the balance beam, earlier or later according to its position as depending on the varying position of the cistern: record intermittent.

1877, Stanley.—Barometrical clock for registering mean atmospheric pressure. *Quar. Jour. Met. Soc.* Vol. III. p. 352.

A barometer forms the pendulum, the number of oscillations of which is read off from dials. Similar in principle to Hall 1851, and Rankine 1853.

1877, Power.—Improved form of mercurial barometer. *Quar. Jour. Met. Soc.* Vol. III. p. 435.

Uses a double column of mercury and an overflow cistern arrangement with his mechanism for reading off proposed in 1875.

1877, Bogen.—Standard siphon barometer. *Quar. Jour. Met. Soc.* IV. p. 70.

A travelling barometer easily put together: filled when required use: at short branch has adaptation of a cap through which passes a screw, carrying at its lower end a point for adjustment to the surface the mercury, and at its upper end a graduated disc which may be ployed for differential readings.

1877, Guthrie.—A sensitive mercury barometer. *Phil. Mag.* Vol. 1877, p. 189.

A horizontal spiral of small internal diameter and containing air bub forms the connexion between the two branches of a siphon barometer larger diameter, thus giving by the motion of the bubble an enlarg scale.

1878, Sprung.—Eine neue Form des Wagebarographen. Carl: *Rep. für E Physik.* Vol. XIV. p. 46.

1878, Schreiber.—Der Barothermograph. Carl: *Rep. für Exp. Physik.* V XIV. p. 471.

The barometer is of the balance form: cistern fixed: tube attached beam: record intermittent.

1878, Arzberger und Starke.—Das Stand-Aneroidbarometer. Carl: *Re für Exp. Physik.* Vol. XIV. p. 730.

1879, Rontgen.—Ueber ein Aneroidbarometer mit Spiegelablesung. Car *Rep. für Exp. Physik.* Vol. XV. p. 44.

In both of these forms of aneroids two or more vacuum chambers a employed, and endeavour made further to increase the accuracy of t micrometrical method of measurement.

1879, Bogen.—Standard cistern siphon barometer. *Quar. Jour. Met. Soc* Vol. V. p. 137.

An improved form of his travelling barometer: employs an electri current and small bell to ensure greater accuracy in the adjustment of th point to the surface of the mercury in the open leg of the siphon.

1879, Cecci.—Meteorological Registers at Montsouris. *Nature,* Vol. XX p. 320.

The recording barometer is the balance barometer of Cecci: tube o iron is fixed: cistern of steel is attached to one end of counterpoisec beam: record continuous.

1880, Draper.—Self-recording barometer. *Report of the New York Centra Park Meteorological Observatory,* December 1880.

Tube fixed: cistern is suspended by long spiral springs and carrie pencil for marking paper drawn forward by clock: record continuous.

1880, Wallis.—Barometer adjunct. *Quar. Jour. Met. Soc.* Vol. VI. p. 164.

Consists of a small microscope for attachment to cistern for more easy adjustment of the ivory point.

1882, Joly.—Electric barometer. *Nature*, Vol. XXV. p. 559.

Proposes to ascertain the reading of a distant barometer, telegraphically connected with the recording station, by measure of the varying resistance of the circuit produced by making the barometric column in its rise and fall expose less or more of a fine carbon thread (having high resistance) forming part of the circuit.

1882, Brown.—Barometers. A paper in *Nature*, Vol XXVI. p. 282.

Writes on many points in the history of barometers.

1884, Christensen.—Signalling barometer. *Specifications of Patents.*

An aneroid barometer has an additional adjustable index, which being set to any given reading the ordinary index on arriving at that reading makes contact with it, creating an electric current which rings a bell.

1884, Gibbon.—Self-recording barometer. *Report of the Chief Signal Officer, U.S.A.*, 1884.

Iron float resting on mercury in short branch of a siphon tube is suspended from the short arm of a lever to whose long arm is attached a thin platinum plate adjusted between two platinum points contact with either of which creates an electric current which by mechanical action, in the one case raises, and in the other depresses a frame carrying a pencil, thus producing a continuous record. [Almost precisely similar to the Hough instrument, excepting that the latter has in addition a type printing arrangement.]

1885, Rung.—Self-recording barometer. Symons: *Monthly Meteorological Magazine*, Vol. XX. p. 119. Was exhibited at the Inventions Exhibition, London, 1885.

A siphon barometer is attached to the short arm of a lever: movement of the mercury, disturbing the equilibrium, thereby causes a differential clock train to shift a weight in one direction or the other as necessary to restore it, at the same time influencing a recording pen, which produces a continuous register.

1886, Primrose.—Electric Meteorological Scale Reader. *Leaflet*, dated 1886.

Designed to record variations of meteorological instruments placed at a distance from the recording station. As applied to the barometer a dipping rod descends into the mercury in the short branch of a siphon tube, and being gradually raised from a definite point indicates, by a change in the character of the distant telegraphic record, when the rod has arrived at the surface of the mercury.

1886, Redier.—Nouveau baromètre enregistreur à mercure. *Descriptive pamphlet* dated 1886.

The later of two forms of his mechanical barograph. Here the barometer is at rest. A differential clock train keeps a light horizontal arm in continuous slight vertical oscillation close to the point of a stalk rising from the mercury in the lower branch of a siphon tube; the arm following the stalk in all its variations of position, the barometric variations, through a pencil, become thus continuously recorded.

"NOTE ON THE PROBABILITY OF WEATHER SEQUENCE." By LIEUT.-COL. C. K. BROOKE, F.R.Met.Soc.

[Read April 21st, 1886.]

IN a paper read at the Meeting of the British Association at Aberdeen, 1885, Mr. H. Courtenay Fox, F.R.Met.Soc., ennunciated laws which he considered regulate the sequence of mean temperature and rainfall in the climate of London, based on observations extending over the last seventy years. These laws offered points of considerable interest, as indicating a possible method of obtaining a rough probability of the ordinary sequence of the "weather characteristics" in any locality.

Before, however, applying Mr. Fox's laws to any other locality, it is necessary to assign numerical values to the "weather characteristics" made use of in his paper, and in the following analysis the undermentioned values have been employed with regard to the climates of Cobham and Chiswick.

Very warm or very cold { = ± 8° of mean monthly temperature, from April to November inclusive.
= ± 5° of mean monthly temperature, from December to March inclusive.

Warm or cold ... ... { = ± 1°·5 of mean monthly temperature, from April to November inclusive.
= ± 2°·5 of mean monthly temperature, from December to March inclusive.

Very wet or very dry = ± ⅔ of mean monthly rainfall.

Wet or dry... ... ... = ± ⅓ " "

These values have been applied to the data in the *Cobham Journals* and Mr. Glaisher's *Reduction of the Chiswick Observations* for the twenty-five years 1826-50; and the following results have been obtained:—

Extract from Mr. Fox's Paper.			Cobham.			Chiswick.		
Characteristics.	Month.	Month following.	No. of Cases.	Agreed.	Disagreed.	No. of Cases.	Agreed.	Disagreed.
Very Cold	January, April, June, July, Aug., Sept., Dec.	Cold	26	13	13	19	9	10
Very Warm	January	Dry	3	2	1	2	1	1
"	June, July, August	Warm	8	6	2	9	4	5
Very Dry	June, July	Warm	4	3	1	4	2	2
Very Wet	January, March, April	Warm	18	7	11	14	9	5
"	May, July	Cold	4	2	2	6	2	4
Warm & Wet	November, December	Wet	6	3	3	5	2	3
"	January	Warm	3	1	2	3	2	1
Warm & Dry	June and July	Warm	7	4	3	4	2	2
"	August	Wet	2	2	0	3	2	1
Cold & Wet	July, August	Cold	3	2	1	4	2	2
Cold & Dry	December	Cold	4	2	2	4	2	2
"	November	Dry	1	0	1	1	0	1
	Totals		89	47	42	78	39	39

REMARKS ON BEST APPROXIMATIONS.—At Cobham 7 very cold Augusts were followed by 5 cold Septembers. At Cobham 3 very warm Julys were followed by 3 warm Augusts. At Cobham 2 very warm Junes were followed by 2 warm Julys. At Chiswick 4 very warm Januarys were followed by 3 warm Februarys. At Cobham 4 warm and dry Junes were followed by 3 warm Julys. At Cobham and Chiswick 5 warm and dry Augusts were followed by 4 wet Septembers.

In 167 cases, 86 agreed and 81 disagreed. In the twenty-eight several months under examination, an approximation took place in six at Cobham, and in one at Chiswick.

Looking broadly at the above results, it appears that the laws indicated by Mr. Fox do not apply to the climates of Cobham and Chiswick: this is almost a foregone conclusion, as the weather characteristics of any locality in the British Isles cannot be expected to show signs of invariability, depending as they do on the passage of storms whose track and distance are essentially variable.

Still, if meteorological authorities would agree to a certain percentage of excess and diminution of temperature and rainfall, as indicating the "characteristics" named in the paper under discussion, it might be worth some one's while to undertake an investigation of several long-continued series of observations, in order to ascertain if even a strong probability exists that the influence of a preceding period is a definite factor in the weather characteristics in a succeeding one.

DISCUSSION.

Mr. Fox said that he would have liked to see Col. Brooke's paper, in order to understand the way in which the subject was treated before offering any criticisms upon it. No one felt more than himself the importance of clearly defining the terms and methods employed. He therefore regretted that the author had based his paper upon a report in *Nature*, which merely gave an extremely brief summary of his conclusions, without any hint of the manner whereby they had been obtained. It was possible that the failures discovered by Col. Brooke were due to his results being founded upon ideas as to what was "very cold," "very dry," &c., which were different from those entertained by himself. He asked, upon what principle the author distinguished results that "agreed" from those that "disagreed"? He also inquired what proportion, say of his twenty-five Augusts, were "very dry" and "very wet" respectively? Mr. Fox then explained the method used by himself.[1] It consisted in taking out, say, all the Januarys, arranging them in the order of their mean temperature, and then dividing the long series (extending over seventy-one years) as nearly as possible into five equal sections. The middle section is then called "average" temperature, the division on either side is termed "cold" or "warm," while the extreme sections are designated "very cold" and "very warm." In a similar way the months and seasons were arranged in regard to their rainfall. He had found this simple and uniform method capable of extensive application, and it was likely to be of considerable utility in enabling us to generalise upon the daily accumulating mass of observations. Mr. Fox then illustrated upon the blackboard one of his propositions,—that "a very dry August is apt to be followed by a wet September," in the climate of London,—showing that after fifteen very cold Augusts

No Septembers were very dry.
2 " " dry.
1 " was average.
5 " were wet.
7 " " very wet.

The probability of a very wet rather than a very dry September (deduced from 15 instances) might therefore be expressed by the number—7. Each of his propositions was accompanied by a similar numerical reference, and he had been very careful to exclude any that were of indefinite or ambiguous character. They were also utterly free from any bias derived from theory.

Mr. Symons suggested that it was essential that some explicit definition of the terms "warm period," "cold period," &c. used by Mr. Fox should be given,

[1] *Reports of the British Association* for 1879 and 1885.

because so long as the terms employed were vague and ill-defined, differences must be expected to occur in the results obtained when Mr. Fox's deductions were applied by different people to other series of observations.

Mr. WHIPPLE said that it was very much to be regretted that such elaborate theories as those put forward by Mr. Fox should be founded on observations from one place only. For instance, in the case of rainfall, it was certainly desirable that the arguments advanced as to the sequence of "dry" and "wet" seasons respectively, if they were to be of any value at all, should be based on long series of observations from more than one station, as rainfall was so extremely variable over even a small district. He had read a paper before the Royal Society with respect to the periodicity of rainfall,[1] and had found that only two series of observations out of ten which he examined gave the same periodicity.

Mr. C. HARDING said that he had read in *Nature* the abstract of Mr. Fox's paper to the British Association, and had tested the statement that "the fact of a very dry August being followed by a wet September is unique." The following rainfall for London, published by the Meteorological Office, hardly justifies the printing of such a statement:—

		In.		In.
1871	August	0·86	September	5·13
1880	„	0·54	„	4·47
1883	„	0·48	„	3·15
1885	„	0·93	„	4·06

Dr. TRIPE thought that in an investigation as to the periodicity of rainfall it was desirable to omit rainfall during storms, as even in the case of a series of seventy-one years the effect of such excessive falls on the average would hardly be eliminated. There would, however, be considerable difficulty in excluding excessive falls due to storms, as it would not be easy to settle upon what should be treated as storm rainfall.

Mr. FOX remarked that he had simply used the published results from Greenwich in carrying out his investigations, and had not in any way attempted to tamper with the figures, as he considered that would at once have rendered his conclusions open to objection. The effect of excessive rainfalls would be gradually eliminated in dealing with a long series of observations.

COL. BROOKE, in reply, said that cases "agreed" when a month having the "weather characteristic" described by Mr. Fox was followed by one having the "characteristic" predicted by him: cases "disagreed" when the "characteristic" of the following month did not accord with Mr. Fox's theory. In the "twenty-five Augusts" at Cobham and Chiswick, one in the former and one in the latter were "very dry": and four in the first-named place and none in the last-named were "very wet." Col. Brooke said that he had brought this paper before the Society in order to show that, at present, it appeared to be perfectly impossible to establish any law as to periodicity or sequence in the weather of any practical use.

THE PRESIDENT (Mr. Ellis) remarked that previous to 1841 there is no authoritative Greenwich rainfall table. The observations before that time did not form part of the regular observatory work, and cannot be guaranteed. [A collected table of Greenwich results from 1841 to 1879, prepared by Mr. Nash, appears in Symons's *British Rainfall* for 1879.]

ACCOUNT OF THE CYCLONE OF JUNE 3RD, 1885, IN THE ARABIAN SEA. By CAPTAIN MAURICE T. MOSS (Communicated by CAPT. H. TOYNBEE, F.R.Met.Soc.).

[Read April 21st, 1886.]

IN most nautical works on the Arabian Sea we find that the authors complain that the information is scanty with reference to Cyclones. The following notes may therefore possess some value.

[1] *Proc. Roy. Soc.* Vol. XXX. p. 70.

On June 3rd, 1885, while in command of the *Inchulva* steamship, I had the misfortune to encounter a most furious cyclonic storm while on my passage to Bombay, being to the east-south-east of Aden at the time.

Previous to meeting this storm I had followed my usual habit of carefully noting the barometer, weather, &c. in my private log, thinking it might be of some use. I now submit a copy of the log, dating from June 1st to 13th, which includes an account of the cyclone, and also of the "burst" of the South-west Monsoon, which was the most violent I have ever experienced.

Several fine steamers foundered and were wrecked during the cyclone, although it was not of large dimensions, from what I can gather from friends who were also in it.

Captain Griffiths, of the *SS. Cairo*, mentioned in the log, told me that he took the first wind of the storm at South-west, backing Southerly, South-easterly, and dying away at East, and he could not have been more than thirty or forty miles distant from me, more to the South-eastward, because he was bound round Cape Guardafui.

On my return passage home from Bombay I coaled at Perim, where I was informed that the storm did not make its appearance until next morning, June 4th, so that it had taken twenty-one hours to travel about 150 miles.

The immense wave that struck us during the storm, and which did so much damage, was never caused by the action of the wind alone, for neither before nor after it were the waves anything approaching to it in size. I think it was caused by some volcanic agency, and in this opinion I am corroborated by others who report being struck by a similar wave. I may mention that both Aden Telegraphic Cables lying on the sea bottom were broken.

Probably this cyclone came from the Eastward, or say South-east by East, and when about Socotra Island curved into the Gulf of Aden, travelling to the West-south-west into the Gulf of Tejureh.

Its diameter could not have been large, but its fury was frightful, I suppose the more so from its being concentrated.

COPY OF PRIVATE LOG KEPT ON BOARD THE S.S. "INCHULVA," OF LIVERPOOL. SUEZ TOWARDS BOMBAY.

JUNE 1ST, 1885.

a.m. Barometer 29·92 ins.; temperature 94°. Calms, squalls from the Eastward and otherwise light variable winds, with hot sultry weather.

8 a.m. Barometer 29·90 ins.; temperature 94°. Weather most oppressive; engineers unable to get sufficient steam on account of the great heat and no current of air through the stoke-hole.

Noon. Barometer 29·89 ins.; temperature 95°. Lat. 16°4 N, long. 41°34′ E, distance run 198 miles. Weather continued in all respects as above.

4.39 p.m. Centre of Jebel Tier Island abeam, distant 2 miles. Course South-south-east, Easterly (magnetic).

9.10 p.m. Barometer 29·89 ins.; temperature 93°. Centre Peak Island (Zebayers) ahead, distant 4 miles. Course South-east by South (magnetic).

JUNE 2nd.

a.m. Barometer 29·89 ins.; temperature 92°. Light variable airs and very hot sultry weather. Sea smooth. Course South-east by South.

Sunrise. Barometer 29·90 ins.; temperature 92°. Sky partially overcast with a very fiery appearance, throwing a glare all over ship.

6.20 a.m. Passed Abu Island, Jebel Zuker. Course South-east ¼ East. Signalled *SS. Cairo*, of Cardiff, bound South in company.

Noon. Barometer 29·88 ins.; temperature 94°. Lat. 13°18′ N, long. 43°7′ E. Course variable, distance run 190 miles. Course South-south-east (magnetic). Light Westerly wind and partially clouded sky, atmosphere hazy.

5·40 p.m. Barometer 29·86 ins.; temperature 94°. Passed Perim Island and set course South-east ¾ East (magnetic).

Sunset. The sky looked very bad—green, red, yellow, all mixed up together, and the atmosphere most oppressive, its effects felt by all on board.

8.0 p.m. Barometer 29·80 ins.; temperature 92°. Lightning to North-east by East. Very dirty looking weather. Wind West, freshening.

11 p.m. Barometer 29·78 ins.; temperature 94°. Wind hauling Northerly, in which quarter the lightning was incessant, the sky having a red glare all over. Called all hands, securely furled all sails and awnings.

JUNE 3RD.

a.m. Barometer 29·70 ins.; temperature 95°. All hands securing everything movable about the decks.

12.50 a.m. Altered course to East ¼ South. Log 111 miles.

2 a.m. Barometer 29·70 ins.; temperature 95°. The lightning, forked and chain, was simply blinding, flying about in all directions. Light hot airs from all points of the compass, with showers of rain occasionally.

I had now made up my mind that all the indications pointed to a storm, but thought it would likely be only what I had experienced before at the burst of the South-west Monsoons, and did not feel particularly anxious; still, had everything prepared, double lashings on boats, hatch bars all on, with additional lashings across the hatches from ring-bolt to ring-bolt on either side, extra gaskets on sails and awnings, &c.

It was a mercy we lashed the hatches as above, or nothing in the world would have saved the ship from foundering afterwards when the tarpaulins were blown to pieces.

4 a.m. Barometer 29·70 ins.; temperature 95°. Noticed a swell making up from the Eastward (which alarmed me for the first time). Lightning still flying about but less incessant.

6 a.m. Barometer 29·65 ins.; temperature 95°. Easterly swell getting heavier, though without any top, but much more force.

8 a.m. Barometer 29·60 ins.; temperature 95°. Swell very heavy and running with much force. Sky covered with heavy clouds rolling one over the other from the Northward with a most sullen glare over the whole.

From appearances, &c. I now made my mind up that we were certainly in for a storm; bolted engine-room, cabin, galley and stokehole skylights securely, intending to run a few miles further, anxious to know where the storm was.

8.30 a.m. Barometer 29·58 ins.; temperature 95°. A perfect deluge of rain fell, light hot airs from all points. Lightning and thunder.

9 a.m. Barometer 29·40 ins.; temperature 95°. Wind setting in from North by East, and rapidly increasing, raining as above, tremendous East swell, with a sea getting up over it from the North-north-east. Headed ship North and steamed away full speed.

9.30 a.m. Barometer 29·30 ins.; temperature 95°. Wind hauling Easterly, about North-east by North, with a terrific squall blowing with rain. Lightning flashing and darting here and there through the gloom. Sea seeming to come from all quarters, flying over the ship, rendering objects obscure except just at hand.

10 a.m. Barometer 29·00 ins.; temperature 95°. Wind North-east by North, blowing a perfect cyclone, with fearful squalls. Tried to get ship's head to North-west, but although the helm was hard-a-starboard and engines going full speed, she would not stir her head from North, the great swell from the East running under a North, North-north-east, and North-east sea keeping her in irons, as it were. Kept the engines going with the object of getting as far as possible from the centre of the cyclone.

10.45 a.m. Barometer 28·80 ins.; temperature 95°. Slowed engines and headed ship North-east, at which point the wind now was.

11 a.m. Barometer 28·80 ins.; temperature 95°. Wind North-east, blowing a terrible cyclone; ship lying head North-north-east. Sea not very heavy but

seemingly running anyhow, up in pyramids, and flying over the ship in a continued sheet of spray.

About 11.20 a.m. the uproar was simply deafening, the wind, lightning, &c. appalling, when from my position forward and to leeward of the chart-room on the bridge I saw a frightful sea on port beam, coming at railway speed, as high as our fore-yard, sending all over the other jumbled-up seas before it, and in an instant it struck us, throwing us on starboard beam ends, burying us so completely and in such a manner that for some moments it was impossible to tell whether the ship was going down or not. I scrambled and fought my way through the rushing water and steam from the starboard side where the sea had thrown me, and about now the ship righted herself.

When I got on the bridge I found the storm had lulled just a little, and rain and spray eased sufficiently to allow me to see the serious damage done; port boats gone, iron davits bent double and broken, engine room, cabin, galley sky-lights smashed, stokehole coverings gone, and the tarpaulins of Nos. 1 and 2 holds literally torn to shreds. No. 1 smashed in altogether, the sea pouring into holds and engine department, and the whole deck looked a wreck.

Almost immediately again the squalls came down with a force and fury that I have no words to describe. The lightning seemed now overhead. Wind shifting to East by North.

Noon. Barometer 28·50 ins.; temperature 95°. I got a sight of the aneroid, the hand of which was pumping up and down from 28·40 ins. to 28·60 ins.; lat. about 12°15′ N, long. 45°58′ E, variable courses, distance run 200 miles.

12.30 p.m. Barometer 28·60 ins.; temperature 95°. Wind East, no alteration, ship tumbling about very heavily as if considerable water were in her. Just before looking at the barometer last, there appeared an arch of light to the Eastward and the worst of the lightning appeared to me to be to the southward of us.

1 p.m. Barometer 28·70 ins.; temperature 95°. Wind about East by South, the fury of the storm seemingly being spent, the squalls with less force and the rain much lighter, but the sea very bad, a jumbled-up sort of a sea, running in all directions.

2 p.m. Barometer 28·90 ins.; temperature 95°. Cyclone moderating fast. Wind South-east by East. Engineer reported 4 ft. of water in his department throughout. Bilge pipes choked, bilges full of coals, stokehole plates broken up, &c. &c.

4 p.m. Barometer 29·40 ins.; temperature 95°. Wind South-south-east, ordinary gale, weather clearing up; sea much better. Sounded holds, 4 feet of water in both Nos. 1 and 2.

6 p.m. Barometer 29·60 ins.; temperature 95°. Wind South, strong but moderating fast. Sea going down, weather clearing up.

All hands not disabled clearing away the wreck, engines going slow, ship on her course.

8 p.m. Barometer 29·80 ins.; temperature 95°. Wind light and variable. Lightning to the South-westward.

JUNE 4th.

a.m. Barometer 29·80 ins.; temperature 94°. Light East wind and fine weather with a heavy cross swell, running course. Much lightning to the Southward.

8 a.m. Barometer 29·85 ins.; temperature 92°. Engines stopped; all hands below clearing out coals from engine and stokehole bilges; repairing pump connections, &c.

10 a.m. Spoke an *Alfred Holt* Line Steamer, and signalled to be reported.

Noon. Barometer 29·90 ins.; temperature 94°. Lat. 12°22′ N, long. 47°32′ E, distance run 95 miles.

4.50 p.m. Engines going slow ahead again.

8.0 p.m. Barometer 29·90 ins.; temperature 93°. Wind East, light with fine weather; cross swell still running, but not so heavy as during the morning.

Observed several steamships during the day at different points of the horizon apparently stopped repairing damages like ourselves.

JUNE 5th.

a.m. Barometer 29·90 ins.; temperature 94°. Light variable winds and fine weather. Sea smooth.

Noon. Barometer 29·90 ins.; temperature 96°. Calms, weather getting very

hot again. Lat. 13°14′ N, long. 49°39′ E; course N 67° E; distance run 134 miles.

8 p.m. Barometer 29·84 ins.; temperature 94°. Light variable airs and hot sultry weather. Swell from the Southward.

JUNE 6th.

a.m. Barometer 29·90 ins.; temperature 90°. Light Southerly airs and cooler weather. Swell from the Southward.

8 a.m. Barometer 29·88 ins.; temperature 85°. Lat. 14°19′ N, long. 52°56′ E; course North 71° East, distance run 202 miles. Fresh South wind and clear weather.

8 p.m. Barometer 29·84 ins.; temperature 86°. Wind falling light, sky clear.

JUNE 7th.

a.m. Barometer 29·84 ins.; temperature 86°. Light variable winds and calms, with light passing clouds from North-east and a swell from the Southward.

8 a.m. Barometer 29·86 ins.; temperature 88°. Light South-westerly airs and fine with a little swell from the Southward.

Noon. Barometer 29·86 ins.; temperature 90°. Lat. 15°21′ N, long. 56°20′ E; course North 72° East, distance run 206 miles.

p.m. Light South-west wind and fine weather.

8 p.m. Barometer 29·82 ins.; temperature 90°. Calms and hot sultry weather again. Swell from South-west.

JUNE 8th.

a.m. Barometer 29·82 ins.; temperature 90°. Light South-west airs. Clouds passing from the North-eastward. Swell from South-west.

8 a.m. South-west wind freshening, set sails.

Noon. Barometer 29·81 ins.; temperature 95°. Lat. 15°59′ N, long. 59°57′ E; course North 78° East, distance run 184 miles. Light South-west wind, a little haze over a clear sky.

8 p.m. Barometer 29·80 ins.; temperature 95°. Wind freshening from South-west. Sky clear of clouds but hazy, sea coming up heavy.

JUNE 9TH.

a.m. Barometer 29·76 ins.; temperature 93°. Fresh West-south-west wind and cloudy, the clouds going in opposite directions, upper from North-east, lower from South-west. Sea getting heavier.

8 a.m. Barometer 29·70 ins.; temperature 92°. Fresh West-south-west wind and partially clouded sky. Sea heavy from the South-west.

Noon. Barometer 29·75 ins.; temperature 91°. Lat. 16°37′ N, long. 63°0′ E; course North 78° East, distance run 210 miles. Fresh wind, sky covered more, the clouds looking heavier.

6 p.m. Wind West, strong; sky entirely clouded, weather looking very wild, a heavy cross sea running.

8 p.m. Barometer 29·61 ins.; temperature 90°. Increasing wind from West. Lightning to the North-eastward.

JUNE 10TH.

a.m. Barometer 29·58 ins.; temperature 90°. Strong West gale, rapidly increasing with much and most vivid lightning to the North-eastward, and which seems to be approaching ship, a very heavy cross sea, filling the decks fore and aft.

2 a.m. Barometer 29·54 ins.; temperature 90°. Lightning incessant to the North-east and East. Wind West, hard gale and very heavy squalls, with much rain. Took in all sails.

4 a.m. Barometer 29·50 ins.; temperature 90°. Very heavy gale and terrific squalls; turned ship's head to sea West-south-west and slowed the engines.

Noon. Barometer 29·50 ins.; temperature 90°. Lat. 16°37′ N, long. 64°54′ E; course East, distance run 110 miles. Ship making very bad weather.

4 p.m. Barometer 29·50 ins.; temperature 90°. Got ship before the wind and tried to run, but the tremendous sea made clean breaches over her.

6 p.m. Barometer 29·50 ins.; temperature 90°. Laid ship to again, head West-south-west.

8 p.m. Barometer 29·50 ins.; temperature 90°. Furious gale and terrific squalls with downpours of rain. Tremendous sea running, but although breaking aboard, sometimes very heavily, doing no material damage.

JUNE 11TH.

a.m. Barometer 29·50 ins.; temperature 90°. Very heavy West gale and

hard squalls, rain, &c. as before. Ship head to sea, making very good weather. Lightning clearing away.

6 a.m. Barometer 29·54 ins.; temperature 90°. Gale a little better, sea running truer, got ship away before the wind and set lower topsail.

Noon. Barometer 29·56 ins.; temperature 90°. Lat. 16°25′ N, long. 66°20′ E; course South 83° East, distance run 92 miles. Rain not so heavy.

6 p.m. Barometer 29·58 ins.; temperature 90°. Another sea coming up from the Southward, clashing with the West sea and making ship very uneasy.

10 p.m. Barometer 29·60 ins.; temperature 88°. Gale appears broken, sky better. Sea, although troubled and very heavy, much better.

JUNE 12TH.

a.m. Barometer 29·60 ins.; temperature 86°. Strong gale backing to the South-west. Weather finer, stars out at times. Sea running very heavily, large quantities breaking above fore and aft.

8 a.m. Barometer 29·66 ins.; temperature 86°. Wind moderating fast.

Noon. Barometer 29·70 ins.; temperature 86°. Strong South-south-west wind and fine weather, except a hazy atmosphere. Lat. 17°42′ N, long. 69°43′ E; course North 86° East, distance run 208 miles.

8 p.m. Barometer 29·75 ins.; temperature 86°. Wind moderate at South-south-west, with a shower of rain at times.

JUNE 13TH.

Barometer 29·82 ins.; temperature 87°. Moderate South-south-west wind and fine weather; heavy South-west swell; atmosphere hazy.

Noon. Barometer 29·86 ins.; temperature 87°. Off Bombay.

3 p.m. Arrived and moored ship.

DISCUSSION.

Capt. TOYNBEE said the author had given a very lucid account of the weather experienced in a cyclone. The Easterly swell mentioned as occurring while the wind was blowing from the North, showed that an Easterly gale was blowing to the Eastward of the ship, and Capt. Moss acted very wisely in steering to the Northward, by which means he increased his distance from the centre of the cyclone as it passed to the Southward of him. He (Capt. Toynbee) agreed with Capt. Moss in thinking that the heavy Westerly roller which he experienced was not the result of wind, as it was met with in a position where a Westerly wind had not been blowing; and, so far as he could understand the case, no Westerly gale was or had been blowing to the Westward of the ship's position.

Mr. LAUGHTON thought that Captain Moss's suggestion of the volcanic origin of the tremendous wave or "roller," which did so much damage, was probably correct. If not, he did not see how it was to be accounted for. It came up not only against the wind, but against the direction of any storm wave or current, and did not seem to be in any way connected with the cyclone; though its happening at that particular time was certainly a very curious coincidence.

Mr. SCOTT remarked that this storm had been very fully discussed in France. A French despatch boat and a German frigate were lost in it.

Col. BROOKE said that he had experienced a cyclone at Hongkong in 1875; warning of its approach was given by the naval authorities. When the barometer commenced to fall rapidly, the strength of the wind increased proportionately with the fall, while the gusty squalls similarly increased in intensity and frequency; but on the barometer commencing to rise, after a stationary period of inappreciable extent, the wind fell almost immediately.

Mr. SCOTT said that any one examining the automatic traces in the *Quarterly Weather Report* would frequently find instances where the wind had been blowing hard with a falling barometer, but immediately the mercury commenced to rise the wind ceased.

Results of Solar Radiation Observations in the Neighbourhood of Birmingham, 1875-1884. By Rupert T. Smith, F.R.Met.Soc., M.Inst.C.E.

[Read April 21st, 1886.]

The physics of this little known subject have been variously described as governed by the elastic force of aqueous vapour, by the influence both of cloud and sky freedom from cloud, and by the influence of various wind directions, either by consequent dryness of atmosphere, or by consequent lowness of atmospheric temperature.

No definite results as to these theories are to be gathered from a study of the following ten years' observations, but so far as these have been collated the facts go to show that the approach to the subject of insolation is of difficult access, and that the right study of solar radiation must embrace other considerations than those with which it has hitherto been connected.

The facts of this paper are based upon observations made at four different stations situate within ten miles of Birmingham and upon its west side. The height of the stations varies from 501 to 885 feet above sea-level. The situations and exposures of the instruments (except for the time March 1880 to November 1882, when they were indifferent), were fairly good at the other three stations. The thermometers are all made by Hicks and compared at Kew, the black-bulb thermometer *in vacuo*, which was verified before insertion in its jacket, was the same throughout. The period under observation includes July 1875 to December 1884, being nine years for the months January to June and ten years for all the other months. The figures, except where otherwise stated, represent solar radiation, *i.e.* the difference between the black bulb thermometer *in vacuo* and the air maximum thermometer.

Table I. is evidence that the usual entry of maximum solar radiation once a day is crude and perfunctory. For instance, on May 23rd and 24th, 1884, the weather being peculiarly suitable, hourly observations were made with results as follows:—

TABLE I.

May 23rd.	Sunrise to—5.	5—6	6—7	7—8	8—9	9—10	10—11	11—Noon	Noon—1	1—2	2—3
	Dry										
B. B. Therm. ..	55°	68°	83°	97°	106°	112°	118°	122°	122°	123°	122°
Air Max.	48·6	51·0	55·7	60·0	64·5	68·4	71·2	72·7	73·8	75·4	76·3
Sol. Rad.	6	17	27	37	41	44	47	49	48	48	46
24th. Sol. Rad.	7	18	29	38	42	46	49	51	51	51	48

May 23rd.	3—4	4—5	5—6	6—7	7—to Sunset.	Highest reading.	Means.	V. T.	Cloud.	Wind.
								In.		
B. B. Therm.	118°	110°	102°	85°	69°	123°	100·8°			
Air Max.	76·2	75·8	74·1	71·8	61·5	76·3	67·3	·283	0	E—2
Sol. Rad.	42	34	28	13	7	49	33·4			
24th. Sol. Rad.	44	38	29	17	7	51	35·3	·292	0	E2—3

These two days were cloudless from sunrise to sunset, with, however, a slight haze, as is usual in such bright weather, but still much slighter than fine weather haze later in the summer. The weather was anticyclonic, and an East wind blew with a force 2 on the 23rd, and 3 on the afternoon of the 24th. The two days were so similar as to be unusual. We see in the readings of the first day the maximum of the sun thermometer occurred about 1·45 p.m., while the maximum of air temperature occurred at 3 p.m., and that the difference of readings of these thermometers between these hours of maxima, which alone is that usually entered as solar radiation, is less than the differences of the three readings about noon by 1° and 2° respectively. The difference between the two maxima is 46°·7, while the mean of the sun shining all day without a trace of cloud is only 38°. On the 24th, which was a day of 2° warmer mean air temperature, the difference between the two maxima (127° and 76°·4 respectively) is 51°, while the mean of the sixteen hourly observations is 35° only. Now the next day (25th), the vapour tension and weather generally being the same, except with an amount of cloud at 9 a.m. equal to 4, composed of cirrus drifting from South-west and cumulus blowing over from the East, the solar radiation at 10 a.m. was equal to that of the 23rd at the same hour, and at noon, after only some half hour's sun altogether from sunrise, it had reached 55°. This day was, however, colder than the 23rd by 5°, and there is no doubt that low readings of the maximum air thermometer are the cause of such apparent sun heat where, as a matter of fact, the whole of this particular day, the 25th, was decidedly cool, and no single flush of hot sunshine occurred, the maxima of sun and air thermometers being respectively 117° and 63°·1 only on this day. These three days of May 1884 were all in excess of the mean air temperature, the 23rd and 24th being 6° and 9° in excess, but the weather was beyond question the most tropical in character that has occurred at the dates for ten years, and yet the average solar radiation of these two days for ten years is 40° and 41°, this year showing only, as has been seen, 47° and 51°. The inference here is that in clear sunshine solar radiation is largely dependent on maximum air thermometer readings.

Having quoted the readings of these particularly brilliant May days as evidence of the crudity of the present state of our book observation of solar radiation, let us now proceed to the reputed connection of solar radiation with vapour tension. For this purpose the following tables (p. 182) are given, which fairly explain themselves.

If intensity of solar radiation is caused by a low force of elasticity of aqueous vapour, we may expect to find the march of solar radiation and vapour tension to be synchronous, but in an inverse relation. Now we know that the march of vapour tension is with air temperature; that is, half the year to midsummer it increases and half the year to midwinter it decreases. The march of mean solar radiation is an eccentric one, the ascending portion being one-third of the year exactly, and the descending portion being two-thirds of the year exactly. This is the first and most obvious fact. The mean vapour tension during the ascending third of the year's wave of

TABLE II.

SOLAR RADIATION.—MEANS FOR THE TWO PERIODS 1875–9 AND 1880–4.

Month.	1875.	1876.	1877.	1878. Sun-spot Min.	1879.	Mean.	1880.	1881.	1882.	1883.	1884.	Mean.	Mean for 10 years.
	°	°	°	°	°	°	°	°	°	°	°	°	°
January ..	(13·3)	12·4	9·2	14·0	17·3	13·2	23·1	8·6	5·8	11·8	17·7	13·4	13·3
February ..	(26·9)	31·8	20·3	21·5	29·4	26·0	39·0	23·6	21·6	28·7	28·0	28·2	27·1
March	(40·2)	45·1	30·7	39·9	36·7	38·5	43·6	42·0	34·4	48·6	36·7	41·1	39·8
April	(42·7)	47·7	34·3	45·1	38·6	41·7	44·7	44·3	40·3	46·2	45·0	44·1	42·9
May	(44·0)	42·0	37·1	46·5	45·2	43·0	45·6	41·3	46·2	46·0	45·2	44·9	43·9
June	(42·7)	36·9	37·2	43·2	44·9	41·0	43·3	42·2	44·1	49·9	44·7	44·8	42·9
July	44·0	35·7	34·6	40·2	44·4	39·8	40·3	40·7	43·7	44·6	44·3	42·7	41·3
August	47·4	32·9	34·1	44·2	40·5	39·8	38·4	37·8	40·1	41·3	42·7	40·1	39·9
September	55·5	31·7	29·4	35·1	35·5	37·4	42·8	35·7	38·4	38·0	38·5	38·7	38·1
October	27·1	20·4	20·5	31·4	26·9	25·3	28·4	31·3	38·0	33·4	31·8	32·6	28·9
November ..	17·1	12·0	18·8	22·0	19·5	17·9	14·6	15·3	22·3	30·8	20·2	20·6	19·3
December ..	14·0	8·8	14·4	17·8	16·2	14·2	6·7	6·6	5·0	18·5	22·7	11·9	13·1
Mean	34·6	29·8	26·7	33·4	32·9	31·5	34·2	30·8	31·7	36·5	34·8	33·6	32·5
Spring	(42·3)	44·9	34·0	43·8	40·2	41·1	44·6	42·5	40·3	46·9	42·3	43·4	42·[illegible]
Summer....	(44·7)	35·2	35·3	42·5	43·3	40·2	40·7	40·2	42·6	45·3	43·9	42·5	41·[illegible]
Autumn ..	33·2	21·4	22·9	29·5	27·3	26·9	28·6	27·4	32·9	34·1	30·2	30·6	28·[illegible]
Winter	19·4	12·8	16·6	21·5	26·1	19·3	13·0	11·3	15·2	21·4	20·0	16·2	17·[illegible]

TABLE III.

VAPOUR TENSION FOR THE TWO PERIODS 1875–9 AND 1880–4.

Month.	1875.	1876.	1877.	1878.	1879.	Mean.	1880.	1881.	1882.	1883.	1884.	Mean.	Mean for 9·5 years.
	In.	In.	In.	In.	In.	In.	In.	In.	In.	In.	In.	In.	In.
January	..	·228	·226	·209	·146	·202	·159	·127	·189	·137	·222	·167	·185
February	..	·250	·233	·221	·187	·223	·225	·190	·249	·214	·237	·223	·223
March	..	·188	·205	·202	·202	·199	·219	·194	·236	·164	·218	·206	·203
April	..	·224	·239	·257	·220	·235	·248	·230	·232	·252	·239	·240	·238
May	..	·159	·259	·322	·254	·249	·283	·271	·232	·262	·249	259	·254
June	..	·258	·298	·366	·348	·318	·364	·344	·298	·338	·322	·333	·326
July	·391	·292	·380	·418	·388	·374	·428	·425	·352	·371	·434	·402	·388
August	·429	·300	·395	·429	·393	·389	·429	·405	·370	·412	·421	·407	·398
September......	·421	·235	·319	·362	·347	·337	·419	·375	·300	·379	·358	·366	·352
October	·258	·352	·290	·303	·283	·297	·245	·276	·267	·321	·253	·272	·285
November	·209	·307	·245	·185	·192	·228	·227	·273	·172	·239	·207	·224	·226
December	·179	·232	·216	·158	·169	·191	·236	·185	·128	·281	·158	·197	·194
Mean	..	·252	·275	·286	·261	·270	·290	·274	·252	·281	·277	·275	·272
Spring	..	·190	·234	·260	·225	·227	·250	·232	·233	·226	·235	·235	·231
Summer	..	·283	·358	·404	·376	·374	·407	·391	·340	·374	·392	·381	·378
Autumn	·296	·298	·285	·283	·274	·287	·297	·275	·246	·313	·273	·281	·284
Winter	·219	·230	·215	·164	·184	·202	·184	·208	·160	·247	·164	·193	·198

solar radiation is ·212 in., that of the descending two-thirds is ·308 in. In 9½ years no single year and one month only (March 1883) has a maximum of solar radiation and a minimum of vapour tension, while the mean vapour tension is lower in the months of low radiation and higher in the

months of high radiation. Alone of 114 months, October and November 1876 have minimum solar radiation and maximum vapour tension, while, on the other hand, August and September 1875 and May 1878 have maximum solar radiation and maximum vapour tension. Minimum solar radiation and minimum vapour tension occur in three months.

From these figures it would appear that there is no directly traceable connection between aqueous vapour tension and solar radiation. The effect of aqueous vapour in preventing re-radiation is a different question.

Next comes the connection between solar radiation and cloud.

TABLE IV.

MEAN AMOUNT OF CLOUD FOR THE TWO PERIODS 1875–9 AND 1880–4.

Month.	1875.	1876.	1877.	1878.	1879.	Mean.	1880.	1881.	1882.	1883.	1884.	Mean.	Mean for 10 years.
January	9·4	7·6	6·7	7·1	6·6	7·5	6·9	6·2	6·8	5·0	7·5	6·5	7·0
February	9·0	6·6	6·4	8·5	7·5	7·6	6·1	6·9	8·5	8·7	6·7	7·4	7·5
March	7·7	5·3	5·5	6·0	6·9	6·3	7·7	5·5	5·7	4·6	6·1	5·9	6·1
April	7·5	6·8	7·9	4·8	8·2	7·0	7·8	5·8	6·1	5·0	5·9	6·1	6·6
May	5·7	5·8	6·8	7·5	6·8	6·5	5·2	5·4	5·9	6·1	4·8	5·5	6·0
June	6·5	5·3	5·2	5·1	6·9	5·8	7·6	6·0	7·6	5·2	5·0	6·3	6·1
July	7·7	5·5	7·3	6·0	8·8	7·1	6·8	6·1	6·6	5·6	5·9	6·2	6·7
August	6·2	6·1	6·7	7·5	7·7	6·8	8·0	8·1	6·9	6·8	4·6	6·9	6·9
September	5·7	6·5	6·4	6·2	5·9	6·1	5·5	6·1	5·1	6·1	7·2	6·0	6·1
October	5·9	7·0	5·4	5·2	8·2	6·3	7·1	6·5	7·0	5·9	5·9	6·5	6·4
November	6·6	6·5	4·5	6·1	6·9	6·1	5·2	7·4	4·8	6·8	7·0	6·2	6·2
December	7·8	7·6	4·7	5·8	5·9	6·4	6·7	5·8	..	6·4	7·0	6·5	6·5
Mean	7·1	6·4	6·1	6·3	7·2	6·6	6·7	6·3	6·5	6·0	6·1	6·3	6·5
Spring	7·0	6·0	6·7	6·1	7·3	6·6	6·9	5·6	5·9	5·2	5·6	5·8	6·2
Summer........	6·8	5·6	6·4	6·2	7·8	6·6	7·5	6·7	7·0	5·9	5·2	6·5	6·5
Autumn	6·1	6·7	5·4	5·8	7·0	6·2	5·9	6·7	5·6	6·3	6·7	6·2	6·2
Winter	7·3	6·9	6·8	6·6	6·3	6·8	6·6	7·0	6·9	6·9	7·6	7·0	6·9

Table IV. shows the mean amount of cloud at Birmingham is less than at observed at Greenwich (=6·82); it shows also that there is less cloud spring and autumn than in summer and winter. May is the month of least loud. A characteristic of May weather, however, is less and less cloud as e day progresses, and this is peculiar to May of all the months. The nount of cloud for May at 9 a.m. being 6·1, the amounts at noon and at p.m. may be taken at 5·4 and 4·3 respectively, giving an average of 5·3, hich correction brings May to the top of the list in the matter of freedom om cloud. The average of cloud for the increasing radiation of one-third of e year is 6·8; for the decreasing two-thirds it is 6·4, but the number of oudy days (see Table V.) is more during the increasing one-third by 3·6 ys a month, the monthly average during ascent being fifteen and during scent twelve. The year of least mean cloud (1883) agrees with that of ost solar radiation, as also does that of the least number of cloudy days; at the year of maximum cloud, 1879, was a year of high radiation, although id to be a year of deficient sunshine.

TABLE V.

NUMBER OF DAYS OF FULL CLOUD IN THE TWO PERIODS 1875–9 AND 18

Month.	1875.	1876.	1877.	1878.	1879.	Mean.	1880.	1881.	1882.	1883.	1884.	Mean.
January	27	19	17	15	14	18·4	20	17	19	..	17	18·3
February	21	13	14	19	17	16·8	14	16	20	..	10	15·0
March ..	19	10	11	12	18	14·0	11	13	10	11	12	11·4
April	17	11	17	9	18	14·4	18	10	12	9	10	11·8
May	10	8	13	15	12	11·6	11	11	9	10	9	10·0
June	8	6	8	10	12	8·8	16	12	8	6	5	9·4
July	15	10	12	8	19	12·8	10	8	8	4	7	7·4
August ..	11	12	13	15	18	13·8	17	13	10	6	7	10·6
September	6	12	11	13	13	11·0	9	14	6	10	12	10·2
October ..	13	19	13	11	21	15·4	15	11	17	8	14	13·0
November	10	15	8	13	19	13·0	12	16	..	7	9	11·0
December	16	17	5	11	13	12·4	17	12	..	10	10	12·3
Total ..	173	152	142	151	194	162·4	170	153	..	..	122	140·3
Spring ..	46	29	41	36	48	40·0	40	34	31	30	31	33·2
Summer	34	28	33	33	49	35·4	43	33	26	16	19	27·4
Autumn	29	46	32	37	53	39·4	36	41	(37)	25	35	34·3
Winter ..	45	48	39	42	47	44·2	50	51	(46)	37	51	47·3

There appears little to show that the greatest amount of cloud of occurs with any particular wind, but the most cloudy weather markedl at six months' interval in January-February and again in July-Aug the first of these periods it occurs with a decided prevalence of South the second period the prevalence of West wind is more strongly Although July is a month of maximum cloud, yet June and July s least number of "overcast" days of all the months of the year. Ma September, at an interval of six months, show a light amount of cloud. are the months when the incidence of the solar rays is strongest.

Next comes the relation of solar radiation to wind.

The winds designated as polar are the North-west, North-nor North, North-north-east, North-east, East-north-east and East; th torial South-east to West, both inclusive; winds from West-north-w East-south-east and the calm days have been omitted from the di (Table VI.).

Looking generally at the Tables, it is obvious that the curve of me radiation, having its two maxima in spring and autumn, can only be ir influenced by the curve of days of polar wind. Other causes must b for to account for the solar radiation of summer and the gradual d the descending two-thirds of the radiation to its minimum on Janu The polar winds of May blow on an average of 8·8 days in the firs the month, and 5·9 days in the latter half; the first half having radiation on the average. The polar winds of December blow on an of 6·8 days in the first half of the month and 8·7 in the second l radiation of the first half being less than that of the second half 1883, the year of maximum solar radiation, is the year of maximum

TABLE VI.

NUMBER OF DAYS OF POLAR WIND (NW–E) FOR THE TWO PERIODS 1875–9 and 1880–4.

Month.	1875.	1876.	1877.	1878.	1879.	Total.	1880.	1881.	1882.	1883.	1884.	Total.	Mean for 10 years.
January......	2	9	5	14	25	55	14	10	6	4	2	36	9·1
February	18	8	8	7	6	47	4	17	10	2	7	40	8·7
March	19	9	10	17	10	65	19	19	5	19	9	71	13·6
April	10	10	15	13	17	65	13	22	15	14	19	83	14·8
May	7	22	17	6	16	68	19	12	16	15	11	73	14·1
June	9	11	14	13	3	50	11	7	10	11	16	55	10·5
July	15	10	3	18	8	54	7	4	0	8	4	23	7·7
August	10	14	8	7	6	45	19	7	9	2	5	42	8·7
September....	10	8	20	6	8	52	6	16	14	6	9	51	10·3
October	13	9	6	10	17	55	22	23	23	14	11	93	14·8
November	16	14	2	22	19	73	13	6	14	10	12	55	12·8
December	11	6	10	19	9	55	9	5	9	10	12	45	10·0
Total	140	130	118	152	144	..	156	148	131	115	117	..	135·1
Spring	36	41	42	36	43	..	51	53	36	45	39	..	14·1
Summer......	34	35	25	38	17	..	37	18	19	21	25	..	9·0
Autumn......	39	31	28	38	44	..	41	45	51	30	32	..	12·6
Winter	28	19	31	50	28	..	36	21	15	19	26	..	9·1

TABLE VII.

NUMBER OF DAYS OF WIND DIRECTION FOR TEN YEARS 1875–1884.

Month.	NW.	NNW.	N.	NNE.	NE.	ENE.	E.	Average Polar Wind.	SE.	SSE.	S.	SSW.	SW.	WSW.	W.	Average Equatorial Wind.	ESE.	WNW.	Calm.	Average Neutral and Calms.
anuary	9	8	11	4	16	9	34	9·1	17	11	39	27	44	12	36	18·6	4	11	17	3·2
'ebruary	26	2	17	3	16	8	15	8·7	17	7	39	19	40	6	45	17·3	8	9	6	2·3
farch	24	4	26	11	30	13	28	13·6	5	6	16	15	33	10	56	14·1	6	17	5	2·8
.pril	16	5	8	15	43	10	51	14·8	15	11	25	16	33	5	23	12·8	7	5	12	2·4
fay	16	6	22	8	38	13	38	14·1	8	3	24	22	39	6	33	13·5	2	17	15	3·4
une	21	9	14	5	21	8	27	10·5	10	2	20	20	57	12	44	16·5	16	7	7	3·0
uly	33	12	10	0	5	6	11	7·7	7	1	23	26	63	18	58	19·6	2	25	10	3·7
.ugust	18	6	12	2	28	3	18	8·7	14	7	21	24	55	16	57	19·4	8	16	5	2·9
eptember	26	9	15	5	21	5	22	10·3	10	4	24	10	50	13	43	15·4	7	22	14	4·3
'ctober	31	16	11	11	26	7	46	14·8	11	3	18	13	46	9	27	12·7	6	15	14	3·5
'ovember	26	13	20	17	18	9	25	12·8	9	3	27	24	33	13	41	15·0	2	13	7	2·2
'ecember	33	9	15	5	15	6	17	10·0	11	9	26	18	61	20	32	17·7	8	14	11	3·3
verage for One Year	28	10	18	9	28	10	33	..	13	7	30	23	55	14	50	..	8	17	12	..
pring	56	15	56	34	111	36	117	..	28	20	65	53	105	21	112	..	15	39	32	..
ummer	72	27	36	7	54	17	56	..	31	10	64	70	175	46	159	..	26	48	22	..
.utumn	83	38	46	33	65	21	93	..	30	10	69	47	129	35	111	..	15	50	35	..
Vinter	68	19	43	12	47	23	66	..	45	27	104	64	145	38	113	..	20	34	34	..

days of polar wind blowing if East-south-east wind be included. 1877, the ar of minimum solar radiation, is the year of maximum number of days of uatorial wind direction. The solar radiation of all polar winds is about

$2\frac{1}{2}°$ higher than that of the equatorial winds, but only $0°·7$ higher than the yearly average. The greatest influence of polar wind upon radiation is in March. The maximum of the mean solar radiation curve in May has been attributed to wind, and especially to polar wind, but as seen from Table VIII. the points of greatest radiation in that month are respectively South by East and West-north-west, one of which certainly is an equatorial wind, while the resultant wind of radiation for May is South-south-west, also an equatorial wind; the North-west, North-north-west and North winds are decidedly deficient in radiation during that month.

Table VIII. shows the relation between wind direction and maximum radiation through the year. Commencing the first week in January the maximum comes from the North, it continues to move slightly westward until February when it turns eastward slightly until March, from which time until July it progresses rapidly eastward till it is found at West-south-west in July, when the change again occurs and the direction again becomes westward to August and less rapidly westward till September, when it again changes to Eastward and again reaches West-south-west in October, from which, however, it turns again westward to North-north-west by the North in November, when it moves eastward to North-north-east in December to finally move slightly westward again to the North in January. Similarly the curve of minimum radiation at an angle of about 150° runs parallel to that of maximum radiation until April, from when it becomes flatter till May when it rapidly backs to East-north-east in July, from when it slowly returns westward to South by East in December and so eastward again to East-south-east in January. In none of the months is there either maximum or minimum radiation to the West, West-north-west, or North-west points.

Thus far we have viewed radiation in connection with vapour tension, cloud and wind. Turning again to Table II. for mean solar radiation, let us examine it in detail and see what it affords. First of all, the year 1883 is the year of maximum radiation, and 1877 that of minimum. We see also that mean radiation reaches its greatest height in May and not in July, and its minimum about the end of the year. The actual dates are May 9th for the maximum and January 8th for the minimum, dividing the year into one-third for the ascending period of increasing radiation, and two-thirds for the descending period of decreasing radiation. The mean temperature of air in the district has its maximum on July 17th and its minimum on the morning of January 12th for this space of ten years. Table XI. in reference to this will be noticed further on.

Taking out the average radiation for every day of the year, and smoothing the curve by taking ten-day means as the solar radiation for the day (sixth), as shown in the steady curve of Table IX., there appear in the ascending one-third of the curve twenty-four days of *minus* sign, these being where counter-checks occur, or an average of twenty per cent., and in the descending two-thirds 131 days of *plus* sign, or an average of fifty-four per cent. In other words, allowing for the first short gradient being double the steepness of the other, the fluctuations up to the maximum about equilibrate those of the

TABLE VIII.

Solar Radiation and Wind Direction for Nine-and-a-half Years 1875–1884.

Month.	Mean Radiation.	N.	NNE.	NE.	ENE.	E.	ESE.	SE.	SSE.	S.	SSW.
	°	°	°	°	°	°	°	°	°	°	°
January	13·2	19·5	12·3	13·0	10·2	12·4	5·3	5·7	8·6	13·1	12·6
February	26·9	28·5	27·3	19·0	13·3	21·4	16·4	24·8	30·4	22·1	29·2
March	39·8	47·8	41·8	45·0	35·0	37·5	27·0	20·3	34·3	42·6	39·5
April	42·9	35·1	50·2	43·9	41·6	41·8	39·7	43·3	41·8	43·1	41·7
May	43·9	41·4	44·9	45·0	44·8	44·4	[1]35·0	44·4	[1]50·5	47·8	44·7
June	42·7	37·1	44·4	43·4	33·2	41·2	39·5	38·4	[1]27·0	44·7	46·6
July	41·2	42·2	..	41·2	28·3	37·9	[1]35·5	43·5	[1]39·0	36·5	40·9
August	39·9	35·0	[1]37·0	39·0	48·7	33·9	39·1	44·8	38·7	40·3	37·0
September....	38·1	38·1	37·8	45·8	40·8	35·0	29·0	38·3	38·0	40·3	37·8
October	28·9	32·5	31·2	28·8	30·7	27·2	20·8	24·9	35·0	24·8	26·5
November	19·3	21·1	23·8	18·2	10·4	10·6	[1]34·5	21·4	9·3	15·5	15·8
December	13·1	15·3	26·4	8·1	18·3	21·4	10·1	8·6	6·7	6·3	9·2
Daily Average	32·4	33·0	35·2	35·5	29·9	31·1	28·3	29·9	27·8	25·0	30·8
Spring	42·2	43·2	46·2	44·6	41·5	41·7	34·1	39·8	41·0	44·5	42·3
Summer	41·3	37·9	42·3	40·8	34·4	38·1	39·1	42·6	36·6	40·1	41·0
Autumn......	28·8	29·4	28·4	31·4	24·4	24·6	26 5	28·3	28·5	26·6	23·4
Winter	17·7	20·9	21·9	12·6	13·4	16·7	11·5	14·6	14·5	14·5	16·1
No. of Days ..	..	165	82	258	83	318	72	119	60	272	226

Month.	SW.	WSW.	W.	WNW.	NW.	NNW.	Calm.	Wind of Radiation.		Resultant.
								Max.	Min.	
	°	°	°	°	°	°	°			°
January	16·2	16·8	14·9	12·5	17·9	15·6	7·5	N	ESE	W 38 N
February	30 8	24·6	27·4	33·9	33·1	[1]35·5	29·2	NNW?	ENE	W 16 N
March	32·2	45·3	41·1	36·6	41·6	47·8	38·0	N by W	SE	N 39 W
April	46·4	38·5	42·8	40·2	47·6	35·2	35·8	NNE	N by W	S 20 E
May	43·9	46·1	41·8	46·4	43·3	42·8	38·6	S by E?	N ?	S 26 W
June	44·7	45·3	42·7	43·1	45·1	43·0	36·1	SSW	SSE	W 12 N
July	42·0	45·3	43·2	41·1	41·1	44·4	36·7	WSW	ENE	W 39 S
August	41·8	43·8	40·3	42·8	39·8	34·8	36·2	ENE	E	S 23 W
September....	41·6	38·5	37·7	38·1	36·7	30·1	27·1	NE	ESE	S 38 W
October	29·9	38·3	34·0	27·4	30·5	29·6	20·5	WSW	ESE	W 30 N
November	15·6	26·6	22·5	21·5	25·8	26·7	14·0	NNW?	SSE	N 41 W
December	12·5	13·1	13·9	13·4	19·0	18·3	7·5	NNE	S by E	N 7 E
Daily Average	33·3	34·0	34·5	33 6	34·6	32·3	25·1	NE	S	W 25·8 N
Spring	41·1	44·1	41·6	41·3	44·0	41 6	37·5	NNE	ESE	N 44 W
Summer	42·7	44·7	42·0	42 0	41·9	41·8	36·4	WSW	ENE	W 3 S
Autumn......	30·8	34·1	31·2	30 6	31·0	28 7	21·8	WSW	ENE?	W 26 N
Winter	18·4	15·8	19·8	18·1	24·0	19·0	10·8	NW	ESE	W 25 N
No. of Days ..	527	135	472	164	272	98	117	..	..	..

[1] Only two observations.

longer gradient down again to the same level. From the middle of June to the middle of July, and again early in August to well into September, there are two unbroken periods of *plus* sign for twenty-eight and thirty-five days respectively, showing that the later summer months have some strong

TABLE IX.

COMPUTED MEAN SOLAR RADIATION OF EVERY DAY FOR TEN YEARS 1875–1884.

Date.	Jan.	Feb.	Mar.	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
	°	°	°	°	°	°	°	°	°	°	°	°
1	11	19	33	42	44	44	43	39	41	35	21	14
2	11	19	34	43	44	44	43	39	41	34	21	14
3	11	20	35	44	44	44	43	38	41	33	21	14
4	10	20	36	44	45	44	43	38	40	32	21	14
5	10	21	36	44	45	44	43	39	40	31	21	13
6	10	22	37	43	45	44	43	39	40	31	21	13
7	10	23	37	42	45	43	44	39	40	31	21	13
8	10 (9·6)	24	38	42	45 (44·9)	43	44	39	39	31	22	13
9	10	24	39	41	45	42	44	40	38	31	22	13
10	10	24	40	41	45	42	43	40	38	30	22	12
11	10	25	41	41	45	42	43	41	38	30	22	11
12	10	25	41	41	45	42	42	41	37	31	22	10
13	10	27	41	41	45	41	42	41	37	31	22	10
14	11	28	41	40	45	41	42	41	37	31	22	10
15	11	29	41	40	44	41	41	41	38	31	22	10
16	12	29	41	41	44	41	41	40	38	31	22	10
17	13	29	41	42	44	42	41	40	38	30	21	10
18	14	29	42	43	43	42	40	40	38	29	21	11
19	15	30	42	44	43	42	40	40	38	29	20	12
20	16	30	43	44	43	42	40	40	38	29	19	13
21	16	31	43	44	43	42	41	40	38	28	18	14
22	17	32	42	44	42	43	41	40	38	28	17	15
23	17	32	42	44	42	43	41	39	38	27	17	16
24	17	32	41	44	42	43	41	39	37	26	16	16
25	18	33	41	44	43	43	41	40	37	26	15	16
26	18	33	42	44	43	43	40	41	37	25	14	16
27	18	33	42	44	43	43	41	41	36	25	14	16
28	18	33	42	44	43	42	41	41	36	24	13	16
29	18	..	42	44	44	42	41	40	36	23	13	15
30	19	..	42	44	44	42	40	40	35	22	14	14
31	19	..	42	..	44	..	39	40	..	22	..	12
Range	9	14	10	5	3	4	5	3	6	13	10	6

influence at work holding up and raising the level of radiation at this time of year. This influence is due to astronomical position, as will be seen in discussing Table XI. The high radiation of the latter part of December is remarkable. Another noticeable point, but one not shown by any of the present tables, is that the months of greatest solar radiation fluctuations are those before the maximum and minimum, namely March and November. Another point is that the radiation of the district under discussion, owing doubtless to the smoke canopy from which the westerly neighbourhood of Birmingham derives its name of the "Black Country," is some 8° less than that of the average radiation of the country, taking western and eastern stations together. The highest radiation was 78° on March 9th, 1888, with snow the day before. The radiation on calm days is 25°·5. No radiation occurred on forty-one days in ten years. The period of Maedler's cold days of May is one of high radiation, as also is that of the November wave of barometric pressure.

In taking out the range the period of indifferent exposure, March 1880-November 1882, has been left out of the reckoning.

TABLE X.

Maximum Solar Radiation 1875–1884.

Month.	1875.	1876	1877.	1878.	1879.	1880.	1881.	1882.	1883.	1884.	Mean.	Range.
	°	°	°	°	°	°	°	°	°	°	°	°
January......	(22)	43	25	39	43	49	29	14	43	48	36	24
February	(35)	56	46	37	54	51	56	40	52	45	47	19
March	(60)	72	45	65	57	55	61	50	78	51	60	33
April	(60)	66	67	59	55	55	60	57	60	66	61	12
May	(50)	64	59	59	56	58	56	57	60	57	58	8
June	(50)	60	51	56	58	55	53	56	60	56	56	9
July	60	55	49	55	60	52	55	50	54	56	55	11
August	68	48	47	57	55	63	52	59	55	53	56	21
September....	71	48	46	52	58	55	50	56	52	50	54	25
October	54	47	37	49	45	54	50	50	50	47	48	17
November	51	30	52	47	45	40	28	34	45	61	43	31
December	45	33	36	36	39	20	12	25	35	66	35	41
Mean	52	52	47	51	52	51	47	46	54	55	51	..
Maximum	71	72	67	65	60	63	61	59	78	66	66	..

TABLE XI.

Solar Radiation.—Highest Readings during the Ten Years 1875–84.

Date.	Jan.	Feb.	March.	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Mean.
	°	°	°	°	°	°	°	°	°	°	°	°	°
1	33	37	53	58	60	59	51	56	61	49	38	34	49
2	45	46	54	54	51	58	60	52	48	50	37	37	49
3	18	40	43	58	53	60	59	48	63	54	29	36	47
4	24	43	54	60	59	52	53	50	63	54	44	35	49
5	39	47	43	58	55	53	58	53	66	50	37	34	52
6	39	43	48	59	54	52	56	59	64	54	54	25	51
7	28	38	72	60	54	50	56	51	65	51	51	20	50
8	26	32	75	56	56	53	55	55	58	46	45	24	49
9	18	39	78	57	53	51	53	55	58	44	34	42	49
10	31	40	71	49	64	54	55	50	63	46	52	20	50
11	24	40	48	53	59	56	51	56	63	50	38	33	48
12	22	40	50	48	56	52	55	52	52	47	47	25	46
13	15	42	59	66	57	52	57	50	54	45	41	24	47
14	26	40	45	48	56	50	52	57	55	49	40	21	45
15	27	40	65	52	55	56	47	51	52	44	45	26	46
16	33	43	64	63	56	56	53	50	56	48	40	31	49
17	49	48	69	66	58	57	50	50	60	45	40	28	52
18	43	52	65	52	55	55	51	56	60	47	40	30	51
19	36	51	49	60	56	54	46	55	71	39	41	45	50
20	28	44	55	55	56	52	57	55	58	47	39	58	50
21	26	45	55	59	58	51	57	55	59	45	61	52	52
22	43	51	56	62	59	50	50	60	53	42	52	41	52
23	39	56	57	60	52	60	53	57	57	48	51	35	52
24	39	54	65	67	57	55	59	51	51	50	27	58	53
25	40	49	53	55	54	53	60	53	60	44	29	33	48
26	43	46	58	61	57	53	60	53	63	44	32	39	51
27	48	55	56	54	55	53	56	68	59	43	28	66	53
28	43	56	52	66	58	47	49	58	48	38	22	24	47
29	29	..	51	50	54	56	53	63	55	43	29	26	46
30	42	..	67	54	54	54	52	62	54	40	38	28	50
31	36	..	55	..	56	..	53	64	..	32	..	43	48
Mean ..	33	45	58	57	56	54	54	55	58	46	40	35	49
Max. ..	49	56	78	67	64	60	60	68	71	54	61	66	53
Min. ..	15	32	43	48	51	47	46	48	48	32	22	20	45
Range	34	24	35	19	13	13	14	20	23	22	39	46	8

This being so, we have taken out the following table. Table XI. shows the highest reading taken on the dates in ten years, and this gives a very interesting result, as it puts a different face upon things,—instead of a single May maximum we have here two maxima, well and clearly showing that March and September, or to speak more nearly, nine days before the spring and twenty days before the autumnal equinox, the times when we experience for a few days what would be the constant state of our climate if the sun moved in a plane coincident with the equator, are the periods of the maximum effect of solar rays; the average maximum radiation of March 12th and September 3rd being 62°—the average maximum radiation of March 21st and September 23rd being 59°. March to September inclusive only vary 4° in their means, themselves being the only months with readings over 70°. The mean of the maxima of every day of every month only gives a range of 8° throughout the 31 days of the months. The high readings in the latter half of December are again seen here, while not far away is the distinctly marked minimum of January 12th, 25°. The line showing the ranges of maximum of the months is interesting, the steadiest maxima being in May, June and July, and the most fluctuating being when the sun is farthest away in influence.

Following up this clue to two maxima at the equinoxes where we have usually noticed one only in May, let us show in the twelfth and last table a statement of nocturnal radiation for ten years—the differences between the minimum air thermometer at 4 feet above the ground and the minimum on grass.

TABLE XII.

NOCTURNAL RADIATION FOR THE TWO PERIODS 1875–9 AND 1880–84.

Month.	1875.	1876.	1877.	1878.	1879.	Average.	1880.	1881.	1882.	1883.	1884.	Average.	Local Average for 10 Years.
	°	°	°	°	°	°	°	°	°	°	°	°	°
January	1·4	−0·6	1·9	0·5	0·1	0·7	0·3	1·7	2·8	1·9	5·4	2·4	1·6
February	0·6	0·5	2·0	1·8	0·4	1·1	1·6	2·1	3·0	3·6	4·1	2·9	2·0
March ..	0·0	1·6	1·4	1·3	0·5	1·0	1·2	3·4	3·7	1·8	4·3	2·9	2·0
April	..	1·1	0.9	0·1	0·3	0·6	1·6	2·5	4·2	3·6	4·8	3·6	2·3
May	1·4	..	0·8	0·2	1·3	0·9	2·6	4·1	6·0	3·5	3·6	4·0	2·6
June	0·0	3·0	−0·4	1·0	1·9	1·1	2·4	3·5	5 6	3·4	3·2	3·6	2·4
July	−0·3	0·4	−0·5	−0·4	2·6	0·4	2·5	3·1	5·9	4·6	6·2	4·5	2·5
August ..	1·3	−0·3	−0·4	−0·5	2·8	0·6	1·6	1·8	5·7	4·1	6·1	3·9	2·3
September	0·9	0·2	0·3	0·4	3·6	1·1	1·9	1·9	5·6	4·1	4·2	3·5	2·3
October ..	0·7	1·1	1·8	0·8	3·6	1·6	1·5	1·9	4·8	4·8	4·9	3·6	2·6
November	1·0	1·1	1·9	0·7	2·9	1·5	2·5	1·8	4·8	4·0	4·2	3·7	2·6
December	0·7	1·5	0·3	0·7	2·8	1·2	2·6	1·6	..	5·1	3·9	3·3	2·1
Average	0·7	0·9	0·8	0·6	1·9	1·0	1·9	2·5	4·7	3·7	4·6	..	2·3
Spring ..	0·7	1·4	1·0	0·5	0·7	0·9	1·8	3·3	4·6	3·0	4·2	3·4	2·3
Summer	0·3	1·1	−0·4	0·0	2·4	1·1	2·2	2·8	5·7	4·0	5·2	4·0	2·4
Autumn	0·9	0·8	1·3	0·6	3·4	1·4	2·0	1·9	5·1	4·3	4·4	3·5	2·5
Winter ..	0·9	0·5	1·4	1·0	1·1	1·0	1·5	1·8	2·9	3·5	4·4	2·8	1·9

This is a table not of solar radiation but of re-radiation of terrestrial heat into the atmosphere and space. It shows again the two periods of maxima as in Table XI., but with an amount of lag of about forty days in spring and about forty-eight days in autumn. It also shows more clearly than Table XI. the two periods of minima at their proper three months' intervals in the third weeks of January and July, or shortly after the periods of the sun's greatest southerly and northerly declination. Thus the May maximum is accounted for as governed by the seasons, the earth in our latitudes being then most turned towards the sun. Table XII. being taken as the complement of Table XI. gives us the correction of the apparent anomaly of the eccentric curve of the table of mean solar radiation (Table II.), and Table XI. shows, in its high radiation of the later summer months, the fact that we are then within the zone of greatest heat incidence at that time of the year.

Increased radiation may be expected after heavy rains, because of the filtering which the air receives. Accordingly we find (without giving tables) the excess, taking the day after falls of half an inch and over and the day after continuous rains, is equal to 5½°. The greatest average excess is in February, 11°; the least, after an interval of six months, is in August, 1°; the maximum excess was in January 1884, +32°; the greatest deficiency after heavy rains was in November 1876, −16°.

After violent winds, which remove local atmospheric impurities, we may look for increased radiation, accordingly we have an average excess of radiation on the days after gales, from whatever quarter, equal to 4¾°.

Again, sky freedom from cloud, whatever adverse influence it may exercise on absorption, does undoubtedly increase radiation, so we find (no tables given) the mean excess of the year is 5½°; the greatest average excess of clear sky radiation over the mean is in February, 9½°; the maximum excess was in March 1883, +42°; the maximum deficiency of radiation with clear sky was in May 1878, −27°. Two months, June and July, show a mean deficiency for the ten years of respectively ·6° and ·4°.

It has been suggested that the mean fluctuations of solar radiation about equal those of mean temperature, so we have here taken out for the ten years the monthly cases of agreement and disagreement of the two daily means, allowing + or −4° of difference in the solar radiation daily means, and + or − 2° in the air temperature means, and find that the cases of agreement are to the cases of disagreement as 3¼ : 2; the maximum number of cases of agreement being in October, November and September, and the maximum number of cases of disagreement being in January and December, the actual numbers being for the four seasons :—

Spring	agreements	5	disagreements	0
Summer	,,	2	,,	4
Autumn	,,	19	,,	8
Winter	,,	5	,,	12

This again points to cloud influence, and also to the influence due to our position as regards the sun.

These are the chief data ascertainable from the facts before us. It is

unadvisable to discuss probabilities in this question, but as food for reflection, it may not be amiss to consider the influence of the duration of sunshine in connection with radiation. We have seen how the maximum of mean radiation occurs in May, but it requires bearing in mind, and is a very important point in this connection, that from March 10th to September 8th the solar radiation only fluctuates 5°, and it may be that the May maximum is due to special circumstances and favourable conjunctions such as wind and cloud reaction, and that after all the march of radiation may be shown to be with that of other climatic phenomena and only in appearance eccentric. The tendency of wind and cloud reaction as to this has been already sketched, but it may turn out that long-period observation of the connection of solar radiation with sunshine duration may still further tend to assimilate the curves of this with other meteorological phenomena. The proportion of sunshine in the ascending and descending radiation periods is as 5 is to 7, showing more sunshine during the summer to winter solstice than in that from winter to the summer solstice. The hours of sunshine in May, June, July and August are on an average more numerous than those of all the other eight months put together. It is fair to assume that the reservoir of heat thus created by the sunshine of the months, when so large a proportion of the day consists of sunshine, or at least sun influence upon earth temperature, may affect the maintenance of the later summer and autumn high level of radiation as much as the combined influences of wind and cloud. Again, about the period of the May maximum the duration of sunshine after noon is longer than that of any of the other months. September also, though in a lesser degree, has this additional afternoon sun. If the black-bulb thermometer readings are at a maximum in May about 1.45 p.m., and the air thermometer at about 3 p.m., May with its additional twenty minutes afternoon sunshine has a better chance of a high record or a course of high records than the other months, excepting September, which also has a similar chance though in a less degree, and this is seen as occurring in a marked manner in 1875, when the mean solar radiation was no less than 17° above the average of the other nine Septembers of the period. There is, however, no instance of an exceptionally high mean in May. May, July and August being the months of least mean fluctuation, while September, February and November are those of greatest mean fluctuation of solar radiation. May, June and July are the months of least maximum fluctuations, while December, November and March are those of greatest maximum fluctuations. The absolutely highest fluctuation in ten years was 76° in March, and the lowest 45° in January and December. The year of minimum sunspots, 1878, was one of average radiation.

It is likely that ebullitions of the combustion of certain solar gases influence the readings of radiation, and it would be interesting to know what, if any, special ebullitions occurred during September 1875, and during the first twenty days of April 1885, the peculiar radiation of which has been referred to.

In conclusion, the author begs to express his obligations to the papers in the *Quarterly Journal*, notably those of Messrs. Ellis, Whipple, and Stow, in connection with this subject.

DISCUSSION.

Dr. MARCET said that the subject of solar radiation was full of interest, and while much was known concerning that phenomenon there still remained a great deal more to be learned. As an illustration of atmospheric humidity affecting solar radiation, he referred to the extreme heat of the sun on the Peak of Teneriffe, where the air is almost as dry as it is possible to imagine it can be, and where in summer hardly a cloud is to be seen in the sky. Prof. Piazzi Smyth, in his observations made at this place at an elevation of 7,000 or 8,000 ft., reckoned the temperature in the sun to be 212°. The mountains of Switzerland also afforded examples of high solar radiation, the sun's heat at Davos (5,000 ft.) in the winter exceeding that registered at Cannes on the Mediterranean seaside.

Mr. LECKY thought that solar radiation would be greater with damp than with dry air, as he knew that in viewing objects through a telescope a much lower power was required in the moist air of Valencia than in the comparatively dry air of Cork.

Dr. MARCET remarked that on the shores of the Lake of Geneva objects were much more easily discernible at a distance and appeared much closer when the air was moist than when it was dry, which the distinguished natural philosopher, Professor De la Rive, of Geneva, had explained by assuming that the dust floating in the atmosphere is hygrometric, and absorbing moisture on damp days becomes transparent, thereby giving increased clearness to the atmosphere.

Mr. WHIPPLE said he regretted that such elaborate use had been made of observations from a black-bulb thermometer *in vacuo*, as the records furnished by these instruments were by no means satisfactory or trustworthy. In fact, the more he had to do with these thermometers the greater was his conviction that the observations from such instruments were worse than useless for the purpose of theoretical observations based upon comparisons.

Capt. TOYNBEE remarked that relative changes were shown by instruments which did not give absolute values correctly; for instance, an aneroid barometer which did not show the pressure of the air correctly would still show the changes in its pressure. He asked whether some such argument might not be used with reference to the various readings of a black-bulb thermometer.

Mr. STANLEY remarked that his own experience with black-bulb thermometers *in vacuo* led him to believe that it was impossible to attach much value to the indications of these instruments.

Mr. FOX was disposed to agree with Dr. Marcet respecting dry air allowing solar heat to reach the earth more easily than moist air. He drew attention to Prof. Tyndall's experiments on the heating and penetrative powers of luminous and dark heat.

Mr. SMITH, in reply, said his paper only dealt with a local and small portion of the subject. He thought the thickness of the atmosphere was as much a function of radiation intensity as was the angle and the season of the year at which the sun's rays shone upon the earth. He reminded Mr. Whipple that the thermometer used in the observations was verified by himself, and any one part of its register was strictly comparable with any other part.

THE CLIMATE OF KILLARNEY. By the Ven. Archdeacon G. R. WYNNE, M.A., F.R.Met.Soc.

[Read April 21st, 1886.]

Temperature.—The climate is determined partly by its geographical position, placed as Killarney is within 14 miles of Dingle Bay, 18 miles of Kenmare Bay, and 40 miles of Valencia Island. It has thus the benefit of proximity to the South-west Coast, with all the modifying influences of the Gulf Stream.

But the temperature is locally modified, and a decided difference is found to exist between that of Valencia and of Killarney. In Table I. the contrast is exhibited for one year, a period sufficient for the purpose.[1]

TABLE I.

MEAN TEMPERATURE, VALENCIA AND KILLARNEY.

1885.	1st quarter.	2nd quarter.	3rd quarter.	4th quarter.	Year.
	°	°	°	°	°
Valencia	44·5	49·8	58·0	47·6	49·9
Killarney	42·1	48·3	57·1	45·7	48·3
Difference.............	—2·4	—1·5	—0·9	—1·9	—1·6

NOTE.—At midsummer the Killarney weekly mean five times exceeded that of Valencia.

How is this difference brought about? If we examine the maximum and minimum weekly means for 1885 we shall find that the maximum at Valencia exceeded that at Killarney on 19 occasions, and that the minimum at Valencia exceeded that at Killarney on 52 occasions.

In other words, while the Killarney weekly maximum was equal to or above that of Valencia 33 times, the Killarney minimum was always below that at Valencia. The range therefore at Killarney is considerably greater.

The minimum temperatures at Killarney have attracted some notice. Compared with Valencia we find as above, while compared with the actual weekly minima from "Ireland S" for 1885 we find that the Killarney minimum was 14 times in the year lower than that of any other southern station, and 11 times it was as low, including 7 times on which it was lower than that of any of the 17 Irish stations of the Meteorological Office. This is noteworthy when it is remembered that comparison is made, among others, with the central stations, Parsonstown, Kilkenny and Armagh, and the North Eastern Donaghadee.

The mean annual temperature may also be compared with that of "Ireland S." It stands thus for four years past:—

TABLE II.

MEAN ANNUAL TEMPERATURE FOR FOUR YEARS.

Year.	1882.	1883.	1884.	1885.
	°	°	°	°
Killarney[1]	49·5	48·7	49·4	49·6
"Ireland S"	50·3	49·3	50·1	48·4?
Difference................	—·8	—·6	—·7	+1·2?

It might fairly be expected from the reputation for mildness and relaxing air which is borne by Killarney, that the mean temperature would exceed the

[1] It should be noted that the thermometer screen at Killarney stands at a level about 20 ft. above the mean level of Lower Lake.

average of the whole of the island south of the latitude of Dublin; but such does not appear to be the case.

Lastly, comparing the Killarney with the Dublin observations for the four years, we have first to decide whether we shall take the City observations published in *The Meteorological Record*, or those furnished by the Observatory of the Ordnance Department, Phœnix Park.

A comparison shows that the City readings are, on the average, much higher than the Park ones. For the years 1882, 1883 and 1884, the excess of the City monthly actual minima over those of the Park can be seen below: and we give the Table, as it may be judicious to let meteorologists know that the Dublin City observations are exceptional.

TABLE III.

MEAN MONTHLY MINIMA AT DUBLIN.

Month.	City. 1882.	Park. 1882.	City. 1883.	Park. 1883.	City. 1884.	Park. 1884.
	°	°	°	°	°	°
January	40·4	38·3	38·7	35·3	41·2	39·4
February	41·9	38·8	38·9	36·3	39·2	37·1
March	41·2	38·6	33·7	30·0	40·3	37·5
April	41·4	37·9	40·	35·2	38·3	35·2
May	46·3	41·3	45·5	41·3	45·6	41·4
June	49·7	46·3	50·4	46·7	50·7	46·8
July	53·9	49·6	52·5	49·5	54·8	50·9
August	53·6	50·2	53·4	49·4	55·1	51·1
September	47·7	44·1	49·7	45·6	52·1	48·5
October	45·4	41·2	44·6	41·3	44·6	41·7
November	38·9	36·0	39·6	36·1	36·7	35·5
December	33·8	30·7	38·1	34·8	37·4	34·7

Comparing the Killarney minima with the Dublin City Record, we have in the years 1882, 1883, 1884, 31 months out of 36 in which the Killarney mean minimum was lower than that of Dublin. But during that period the Killarney minima were lower than those of Phœnix Park only 5 times.

It is noteworthy that in 1884, when observations in Londonderry began to appear in the *Record*, the Killarney mean minimum temperature was lower than that of Londonderry 5 times.

Lastly, viewing actual minima for the years 1882, 1883, 1884 and 1885, and comparing with Phœnix Park, we have 19 months in which the Killarney minima were lower than that of the Park. (In every month Killarney was lower than the City.) The annual mean of actual monthly minimum temperatures stood as follows:—

TABLE IV.

Year.	1882.	1883.	1884.	1885.
	°	°	°	°
Killarney	29·6	29·1	31·8	28·9
Phœnix Park	28·3	30·7	33·8	28·1

The lowest temperature in the shade in the four years was 11°·5 at Killarney, and 6°·8 at Phœnix Park, in December 1882.

From all the above comparisons it appears sufficiently clearly that Killarney is to be credited with low minimum temperatures, and low mean temperatures consequent on these, as the maxima are comparatively high.

When we ask the cause of the great difference between Valencia and Killarney in the matter of temperature, we do not attribute it mainly to the inland character of the latter station. It is distant but a dozen or 14 miles in one direction from the heat-bearing waters of the Gulf Stream, and the tendency of the large amount of precipitation caused by the mountains which lie between Killarney and Valencia must be to increase rather than to diminish the heat of the air surrounding them.

The solution of the problem seems rather to lie in the fact that Killarney lies in a great irregular basin, surrounded by mountain ranges for about a third, and by hilly plains elevated some hundreds of feet above the lakes on most of the remaining two-thirds of the circle.

The tendency of the heated air to ascend, leaving its place to be occupied by a colder stratum, probably explains the comparative coolness of Killarney at and near the Lake level, a fact established by the observations of the last four years, and one subversive of the popular opinion that Killarney has a very mild climate indeed. The mildness, it would appear, is rather the attribute of the county than of this particular basin, and on the whole, judging from actual minimum readings, or even from mean temperatures, appears to be a character not justified by the facts of the case.[1]

Rainfall.—I shall simply give the Annual Rainfall for the last four years at the three stations in and about Killarney, comparing the figures with those for mean of Ireland, and the Dublin rainfall for each year.

It appears that that which may be an excessively wet year in the South ma be marked by comparative dryness in the East of Ireland, an observation often verified by the comparison of monthly totals.

Amount of Cloud.—Five years' observations bring out the fact that the mean proportion of cloud, varying little with the seasons, is slightly over 7, a proportion which in England is characteristic of towns in the Black Country, and of such places as Bolton.

[1] With a view to determining whether the low minima observed are due to some local conditions applying only to the station at Woodlawn House, or whether these lower minima affect the whole basin in which Killarney is situated, a second station was established on April 1st at the District Asylum, Killarney, at a distance of 1 mile from, and at an elevation of 80 feet above Woodlawn. The results, so far, for the three months (April, May and June) have been :—

Mean of minima at Asylum, April, 38°·8; May, 43°·5; June, 50°·6.
" " Woodlawn, " 39·2; " 42·5; " 49·9.

The mean dry-bulb 9 a.m. temperatures at the two stations were :—

Asylum, April, 49°·0; May, 50°·8; June, 57°·8.
Woodlawn, " 48·3; " 51·1; " 57·8.

(Note added July 1886.)

TABLE V.

ANNUAL RAINFALL.

Years.	Killarney.	Gap of Dunloe.	Mangerton.	Mean Ireland South.	Dublin.
	ins.	ins.	ins.	ins.	ins.
1882	58·13	..	...	40·0	34·8
1883	70·06	102·3	96·0		29·6
1884	63·16	101·9	+83·0[1]		21·2
1885	52·69	89·2	88·1		23·5

[1] In March 1884 the mountain gauge seems to have been choked with snow, and some amount of precipitation has been unregistered.

TABLE VI.

TABLE ILLUSTRATING COMPARATIVE CLOUDINESS.

District and Station.	1882.		1883.		1884.		Mean of all.
	9 a.m.	9 p.m.	9 a.m.	9 p.m.	9 a.m.	9 p.m.	
ENGLAND, N.							
Alnwick (Cramlington 1884)....	6·5	5·8	6·7	5·7	7·3	6·1	6·3
ENGLAND, E.							
Lowestoft	6·8	6·2	6·9	6·2	6·6	5·8	6·4
ENGLAND, MID.							
Cheltenham	7·3	6·4	6·8	5·7	6·7	5·7	6·4
ENGLAND, S.							
Margate	7·5	6·2	6·7	5·3	6·4	5·2	6·2
ENGLAND, S.W.							
Babbacombe..................	7·1	6·1	7·0	5·7	6·8	5·9	6·4
IRELAND, E.							
Dublin	6·5	5·6	6·1	5·6	6·4	5·7	5·9
IRELAND, N.							
Londonderry.............. ..					7·7	6·4	7·05
IRELAND, S.							
Killarney	7·5	6·8	7·6	6·7	7·3	6·5	7·04

NOTE.—Observe (1) The mean ratio of all 9 a.m. readings to all 9 p.m. readings for seven stations during three years is 6·9 : 5·9.

(2) Dublin shows minimum cloudiness, Londonderry and Killarney maximum.

RESULTS OF METEOROLOGICAL OBSERVATIONS MADE IN SELÁNGOR, MALAY STATES, 1879-1884. By A. W. SINCLAIR, L.R.C.P. Communicated by E. D. ARCHIBALD, M.A., F.R.Met.Soc.

[Read April 21st, 1886.]

I SUBMIT herewith (1) abstract of rainfall observations for the six years, 1879-84, at Kwala Lumpor (the commercial capital), situated at the source of the Klang river; (2) thermometrical and rainfall observations taken during 1884 at three out stations, viz.: (*a*) Klang, the principal seaport, situated at the mouth of the Klang river, (*b*) Kajang, representing the source of the Langat river, and (*c*) Kwala Langat (the residence of the Sultan) at the mouth of the Langat river; and (3) an abstract of meteorological observations taken at Kwala Lumpor during the year 1884.

All the instruments are by Negretti and Zambra. The barometer is standard, and mounted in brass.

TABLE I.—Rainfall at Kwala Lumpor, 1879–1884.

Months.	1879.	1880.	1881.	1882.	1883.	1884.	Totals.
	Ins.	Ins.	Ins.	Ins.	Ins.	Ins.	Ins.
January	17·31	4·74	3·81	11·08	4·37	9·21	50·52
February	9·05	6·19	8·04	6·60	10·68	5·10	45·66
March	5·13	9·51	5·48	6·75	9·73	6·07	42·67
April	4·34	7·69	10·36	12·52	12·99	11·31	59·21
May	13·89	7·70	12·37	6·83	7·58	13·95	62·32
June	0·82	1·50	2·53	0·59	0·99	4·35	10·78
July	6·63	5·55	2·77	0·33	1·53	4·61	21·42
August	6·78	8·61	4·61	8·69	3·88	4·36	36·93
September	4·95	8·60	11·43	3·98	5·13	6·08	40·17
October	10·96	5·20	10·66	7·93	9·45	17·52	61·72
November	10·62	8·06	13·65	11·73	10·34	8·12	62·52
December	10·56	11·12	13·88	9·15	8·15	7·94	60·80
Year	101·04	84·47	99·59	86·18	84·82	98·62	554·72

TABLE II.

Abstract of Temperature and Rainfall Observations taken at 9 a.m. at Klang, Kajang, and Kwala Langat, out Stations of the Malay Native State of Selângor, during the Year 1884.

Months.	Klang.				Kajang.	Kwala Langat.			
	Temperature.			Total Rainfall.	Total Rainfall.	Temperature.			Total Rainfall.
	Max.	Min.	Range.			Max.	Min.	Range.	
	°	°	°	Ins.	Ins.	°	°	°	Ins.
January	87·0	68·5	18·5	11·13	No record.	85·2	62·8	22·4	7·78
February	88·8	69·9	18·9	5·16		82·3	61·8	20·5	1·43
March ..	89·7	70·4	19·3	1·63		83·6	61·4	22·2	1·37
April	89·7	71·4	18·3	7·19		84·1	63·5	20·6	8·27
May	90·7	70·9	19·8	11·06		87·4	62·6	24·8	11·74
June	89·3	70·4	18·9	8·09		86·8	62·6	24·2	6·58
July	90·3	71·3	19·0	3·06	3·22	85·7	63·7	22·0	10·73
August ..	89·4	71·3	18·1	7·18	6·35	84·9	62·8	22·1	6·20
September	89·7	70·7	19·0	3·13	2·84	82·4	63·9	19·1	3·20
October ..	89·7	71·0	18·7	11·29	22·47	84·2	64·3	19·9	11·56
November	88·2	71·8	16·4	15·31	12·37	85·1	64·6	20·5	10·00
December	87·7	71·2	16·5	7·65	7·08	85·0	63·5	21·5	7·37
Year ..	89·1	70·7	18·4	91·88	..	84·7	63·1	21·6	86·23

The following is an extract from the *Chronicle and Directory* for Chin Japan, and the Philippine Islands, &c. Hong Kong, 1885 :—

Sélângor.—This is one of the native states of the Malayan Peninsula, an lies between the Dindings and Sungie Ujong on the Straits of Malacca. It boundaries are not accurately defined. The government is administered b the Sultan, Abdul Samat, with the assistance of H.B.M.'s Resident, who ha a staff of English officials. The population of the State is increasing, an was estimated in 1883 at 42,000, of whom 30,000 are Chinese. The tem

TABLE III.

STRACT OF METEOROLOGICAL OBSERVATIONS TAKEN AT KWALA LUMPOR, SELÂNGOR, DURING THE YEAR 1884.

tude 3° 10′ N. Longitude 101° 50′ 6″ E. Height of Barometer 177 ft. above Sea Level.

Months.	9 a.m.						
	Barometer (reduced to 32°).	Tempera-ture.	Relative Humidity.	Amount of Cloud.	Temperature.		
					Max.	Min.	Range.
	Ins.	°	o/o		°	°	°
uary	29·898	79·0	80	5	90·7	69·3	21·4
ruary	·907	81·4	72	4	93·6	69·4	24·2
rch	·887	82·9	72	4	93·2	69·7	23·5
il	·868	82·1	79	4	93·8	71·2	22·6
y	·870	83·0	80	4	96·6	72·8	23·8
e	·883	82·4	79	4	95·2	71·1	24·1
y	·874	81·4	80	5	92·4	70·1	22·3
gust	·882	82·1	77	4	93·7	70·2	23·5
tember	·891	81·9	77	4	93·2	70·0	23·2
ober	·911	81·0	82	4	90·8	69·7	21·1
ember	·896	80·1	80	4	90·3	70·1	20·2
ember	29·906	78·4	81	4	88·2	68·7	19·5
leans	29·889	81·3	78	4·2	92·6	70·2	22·4

Months.	3 p.m.				9 p.m.				Mean Direction of Wind.
	Barometer (reduced to 32°).	Tempera-ture.	Relative Humidity.	Amount of Cloud.	Barometer (reduced to 32°).	Tempera-ture.	Relative Humidity.	Amount of Cloud.	
	Ins.	°	o/o		Ins.	°	o/o		
uary	29·795	84·2	72	6	29·894	73·9	92	6	N
ruary	·771	87·2	58	6	·907	74·4	91	6	Calm
ch	·771	87·7	63	6	·874	74·9	92	5	Calm
il	·742	85·5	72	7	·860	74·9	93	6	Calm
y	·749	88·7	68	6	·873	76·3	93	6	SE
e	·761	85·9	75	7	·873	75·5	93	5	SE & SW
y	·758	88·3	66	7	·867	75·0	92	5	SW
ust	·754	87·4	67	6	·866	75·0	94	6	SE
tember	·762	86·6	65	7	·877	74·7	93	6	SW
ober	·790	83·8	74	7	·900	74·8	93	7	SW
ember	·780	83·1	76	7	·908	74·7	93	7	SW
ember	29·760	84·0	68	6	29·914	73·9	94	6	SE
leans	29·766	86·0	69	6·5	29·884	74·8	93	5·9	..

ure ranges from 57° to 103° Fahr. in the shade. The average annual ll is 91 ins. The chief imports consist of rice, salt, opium, tobacco, d oil; while the exports are tin, garnwood, hides, salt-fish, sago, canes ttans. The revenue for 1883 amounted to $450,664, and the expendi-o $448,708.

EXHIBITION OF BAROMETERS,

HELD BY PERMISSION OF THE COUNCIL OF THE INSTITUTION OF CIVIL ENGINEERS, AT 25 GREAT GEORGE STREET, WESTMINSTER, S.W.

MARCH 16TH, AND 17TH, 1886.

(Illustrations of some of the Barometers are given on Plate 3.)

MERCURIAL BAROMETERS—ADJUSTABLE CISTERN.

1. **Portable or Mountain Barometer,** with ivory float, and vernier reading to ·002 in., by Miller of Edinburgh. Thermometer by P. Bath, Cork. From the observatory of the late Dr. Longfield, of Cork. (See *Phil. Trans.* Vol. LXIX. p. 163.) *Exhibited by* R. J. LECKY, F.R.Met.Soc.

2. **Fortin Barometer,** tube 0·5 in. diameter, with glass plunger to raise the mercury in the cistern. *Exhibited by* P. ADIE.

3. **Fortin Barometer,** with scale figured to tenths of an inch. (Fig. 1.) *Exhibited by* L. P. CASELLA, F.R.Met.Soc.

4. **Fortin Barometer,** with cistern and tubular casing square in section. *Exhibited by* Messrs. NEGRETTI AND ZAMBRA.

5. **Standard Barometer,** by Barrow, the pattern used by the members of the British Meteorological Society about 1850-60. *Exhibited by the* METEOROLOGICAL COUNCIL.

6. **Mountain Barometer,** Fortin pattern, by Negretti and Zambra, in mahogany case, which itself forms the tripod stand. Total weight 4½ lbs. *Exhibited by* G. J. SYMONS, F.R.S.

7. **Improved Mountain Barometer.** (Fig. 2.) *Exhibited by* L. P. CASELLA, F.R.Met.Soc.

8. **Travelling Barometer,** by West, of Fleet Street, with leather bag cistern, scale for capacity correction, divisions on strip of brass attached to wooden mounting, rackwork vernier reading to ·001 in., and attached thermometer arranged for removal so as to be also used to obtain air temperature. *Exhibited by* G. J. SYMONS, F.R.S.

9. **Mountain Barometer,** by Adie, with stand and case. This barometer was originally used by the North American Boundary Commission of 1857, and has since its return been employed on the inter-comparison of the various Standard Barometers of this country, having been designated in the published accounts of such comparisons a "hack" barometer. It has an uncontracted tube 0·5 in. in diameter, and is in a brass case, with a Fortin cistern fitted with Adie's glass plunger instead of the ordinary leather bag. The scale is a continuous one reading from 11·6 ins. to 32·2 ins. and is divided to 0·05 in. There are two verniers permanently fixed 9 ins. apart on an inner tube, which is moved up and down by a rack and pinion. A brass tripod and gimbals are provided for its suspension, and a circular level is attached to the top of the case to ensure its verticality. *Exhibited by the* KEW COMMITTEE.

10. **Self-Compensating Barometer.**—This consists of the usual form of instrument, but with a double rack moved by one pinion, so that when adjusting the vernier in one position the second rack moves in the opposite direction, carrying along with it a plunger which is the exact size of the internal diameter of the tube. This dips into the cistern, so

that whatever displacement has taken place in the cistern owing to the rise or fall of the mercury, it is exactly compensated by the plunger being more or less immersed in the mercury; and consequently no capacity correction is required. (Fig. 3.)
Exhibited by Messrs. NEGRETTI AND ZAMBRA.

Standard Barometer with Electrical Adjustment.—This consists of an upright glass tube dipping into a glass cistern of mercury, so contrived that an up and down movement, by means of a screw, can be imparted to it. Through the top of the tube a piece of platinum wire is passed and hermetically sealed. The cistern also has a metallic connection, so that by means of copper wires in the back of the frame a galvanic circuit is established; another connection also exists by means of a metallic point dipping into the cistern. The circuit, however, can be cut off from this by means of a switch placed about midway up the frame. On one side of the tube is placed a scale of inches with a small circular disc divided into 100 parts connected with the dipping point, and working at right angles with this scale. On the other side of the tube is a galvanometer. When the cistern is screwed up, so that the mercury in the tube is brought into contact with the platinum wire at the top, the needle of the galvanometer is instantly deflected. The switch is then turned, and the dipping point screwed until it makes contact with the mercury in the cistern. The reading is then taken.
Exhibited by Messrs. NEGRETTI AND ZAMBRA.

Negretti and Zambra's New Standard Barometer with overflow cistern adjustment. In taking an observation the mercury in the glass reservoir is screwed up until it covers the inner small tube down which it flows into the lower part or cistern. The screw action is next reversed until the same tube is quite uncovered. The mercury in the reservoir then represents the zero point, from which a correct scale reading of the instrument may be taken. *Exhibited by* Messrs. NEGRETTI AND ZAMBRA.

Stanley's Cheap Barometer.—In this barometer the glass cistern, is raised by a screw until an ivory peg touches the mercury. The reading is taken across the upper edge of a short square metal tube carried by the vernier. The scale is divided on German silver. The vernier reads to ·01 in. *Exhibited by* W. F. STANLEY, F.R.Met.Soc.

Boylean-Mariotte Barometer.—This instrument, which was invented by T. Telford Macneill, consists of a short central glass tube, a lower open-air tube or bulb, with diaphragm joined to it, covered with vulcanite and a brass tube which covers the glass tube and on which the graduations and figures are given. Attached to this is a cistern filled with mercury, which has a stopcock and a screw adjustment. The total length of the instrument is from 12 to 15 ins., but for convenience of carriage the cistern can be detached and carried separately. The atmospheric pressure is measured by an uniform volume of air being admitted to the cistern, and compressed by the advance of the mercury to a fixed point. The readings are taken from two points, as in the Fortin barometer. (Fig. 4.) *Exhibited by* L. P. CASELLA, F.R.Met Soc.

MERCURIAL BAROMETERS—CLOSED CISTERN.

Morland's Diagonal Barometer, the top part of the tube of which is inclined more or less from the perpendicular to give an enlarged scale reading. (Fig. 5.) *Exhibited by* Messrs. NEGRETTI AND ZAMBRA.

Large Cistern Barometer.—This instrument was made for the Meteorological Society of London in 1837 by Mr. R. C. Woods, and cost forty guineas. The proportion of the calibre of the tube to that of the cis-

tern is as 1 : 50, a proportion which was considered sufficient to obviat the necessity for applying capacity corrections. The tube and ciste originally held 70 lbs. of mercury.

Exhibited by the ROYAL METEOROLOGICAL SOCIET

17. **Kew Barometer,** first designed in 1853, tube 0·4 in. in diameter. In th instrument the cistern is closed and the scale contracted, to obviate tl necessity of correction for capacity. *Exhibited by* P. ADI

18. **Marine Barometer,** by Dennis, as supplied to H.M. ships previous 1854. It was used for the meteorological register kept on boa H.M.S. *Rattlesnake* during a voyage to Behring Strait, includi wintering at Port Clarence, 1853-55.

Exhibited by the METEOROLOGICAL COUNC

19. **Kew Marine Barometer,** as adopted by the Admiralty. (Fig. 6.)

Exhibited by P. ADI

20. **Coast Barometer,** by Negretti and Zambra, with plate for exhibiting t certificate of corrections. *Exhibited by the* METEOROLOGICAL COUNC

21. **Gun Barometer.**—The glass tube is packed with vulcanised india-rubber check the vibration caused by firing. (Fig. 6.)

Exhibited by Messrs. NEGRETTI AND ZAMBR

22. **Marine Barometer,** by Newman, used for the meteorological register ke on board H.M.S. *Resolute*, 1850-51. It reads correctly with the Meteor logical Office Standard, but the tube is not sufficiently contracted fo marine barometer. *Exhibited by the* METEOROLOGICAL COUNC

23. **Marine Barometer,** by Ernst, the pattern used in the French Navy in 18(

Exhibited by the METEOROLOGICAL COUNC

24. **Station Barometer** by Tonnelot, as used at the Ecoles Normales in Fran The diameter of the cistern is ten times that of the tube, and the divisio of the scale are shortened accordingly.

Exhibited by the METEOROLOGICAL COUNC

25. **Coast Barometer,** by Salleron, as used in France.

Exhibited by the METEOROLOGICAL COUNC

26. **Marine Barometer,** by Olland, as used in the Dutch Navy.

Exhibited by the METEOROLOGICAL COUNC

27. **FitzRoy Coast Barometer.**—This has a tube with very large bore mount in a solid oak frame, with scales and figures engraved on porcelain, t vernier reading to ·01 in. This form of instrument is now used by t Royal National Life Boat Institution. (Fig. 7.)

Exhibited by Messrs. NEGRETTI AND ZAMBR

28. **Old Barometer,** by Newman, with thick tube, bore 0·2 in. in diameter. T case is of square tubing undivided, and the scale on an inner square tu is moved by a rack and pinion. It is graduated downwards fro 25 ins. to 31 ins. and divided to ·05 in., the vernier being a fixtu screwed to the case, and it reads to ·002 in. The values of the capaci correction and neutral point are engraved on the back. The cistern is iron, closed and provided with Newman's arrangement for portability

Exhibited by the KEW COMMITTE

29. **Portable Newman Barometer.**—The tube is uncontracted, 0·4 in. diameter with 0·25 in. bore, and is tightly embedded in mahoga and protected by sliding mahogany covers. The scale is of flat bra and extends from 20 ins. to 32·3 ins. The vernier slides up and do the scale, friction tight, fine motion being imparted to it by a lo screw lying at the back of the scale, the head of which projects throu the top of the instrument. The cistern is closed, cased in brass, and provided with Newman's arrangement for portability. The values the capacity correction, neutral point, capillary correction and standa temperature are engraved on an ivory tablet inserted in the front of t case. *Exhibited by the* KEW COMMITTE

Portable Newman Barometer with square tubing. *Exhibited by* C. BAKER.

Mountain Barometer, old form, in mahogany frame, with engraved values of neutral point capacity and temperature correction.
Exhibited by C. BAKER.

Portable Barometer graduated on the glass tube, with a sliding vernier, devised by Sir John Richardson, and used by him in the Arctic Regions.
Exhibited by the METEOROLOGICAL COUNCIL.

George's Portable Travelling Barometer, with spiral cord for filling the tube. (See *Quarterly Journal Met. Soc.*, Vol. II. p. 29.)
Exhibited by the KEW COMMITTEE.

Hicks's Spiral Tube Barometer, giving a range of eight inches for one inch variation of atmospheric pressure. (Fig. 8.)
Exhibited by C. BAKER.

MERCURIAL BAROMETERS—SIPHON.

Hooke's Double Barometer. *Exhibited by* R. A. WILSON.

Old Dutch Barometer by Reballio, combining siphon and long range barometer, thermometer and hygrometer. *Exhibited by* M. PILLISCHER.

Gay Lussac Mountain Barometer with vernier to each limb. (Fig. 9.)
Exhibited by Messrs. NEGRETTI AND ZAMBRA.

Mounting of Travelling Barometer formerly belonging to, and used by, De Luc. Presented by the late Prof. John Morris, F.G.S.
Exhibited by the ROYAL METEOROLOGICAL SOCIETY.

Bunten's Siphon Barometer, Paris. The tube is 1 centimetre in diameter; the upper scale extends from 20 to 42 centimetres (graduated upwards); the lower scale from 80 to 40 centimetres (both scales are divided to millimetres). The verniers are moved by small pinions gearing into racks cut on the edge of slits in the tube.
Exhibited by the KEW COMMITTEE.

Siphon Barometer by T. Jones. The tube is about 0·3 in. in diameter. The upper scale is graduated from 24·3 ins. to 33·5 ins. and divided to ·02 in. The lower scale is graduated from 0·0 in. to 9·3 ins. upwards. The verniers are on tubes slipping over the outer case, fine motions being obtained by one part moving over the other.
Exhibited by the KEW COMMITTEE.

Siphon Barometer, by Adie. The tube is 0·5 in. in diameter. There are double scales divided to 0·05 in., the upper reading from 0 in. to 16·6 ins. upwards, and the lower from 0 in. to 15·5 ins. downwards. The verniers are moved by long racks, by means of milled heads and pinions in the centre. *Exhibited by the* KEW COMMITTEE.

Wild's Siphon Barometer as used in Russia. This consists of two tubes, one closed at the top and the other short and open, corresponding to the short leg of the usual form of siphon. (Fig. 10.)
Exhibited by the METEOROLOGICAL COUNCIL.

Mountain Barometer, by Dollond, with leather bag and reservoir, siphon cistern, with tap, for rendering it portable, with detachable thermometer. *Exhibited by* G. J. SYMONS, F.R.S.

Bogen's Barometers, Nos. 1 and 2. The long leg of the siphon is closed at one end, and is supplied with a glass stopper with a fine hole through it at the other. When the tube is filled the stopper is inserted, and, the hole through the stopper being closed by the finger, the tube is inverted and a portion of the mercury allowed to flow away to produce a vacuum. The short leg is of the same diameter, and is formed with a semicircular bend at one end, which is ground to receive the open end of the long

METALLIC, AND OTHER FORMS OF BAROMETER.

63. **Bourdon's Recording Barometer.** In this instrument the drum turning in eight days is supplied with a continuous band of paper, serving for six months or a year. *Exhibited by* Messrs. RICHARD FRÈRES.

64. **Bourdon's Metallic Barometer.** *Exhibited by* Capt. E. H. VERNEY, M.P., F.R.Met.Soc.

65. **Cetti's Glycerine Barometer.** *Exhibited by* E. CETTI.

66. **Jordan's Glycerine Barometer.** The cistern and upper part of the tube only are shown, as the instrument when complete would be about 30 ft. in height. *Exhibited by* Messrs. W. CALLAGHAN & Co.

67. **Stanley's Chrono-Barometer.** The chrono-barometer is a clock that counts the oscillations of a pendulum formed by a suspended barometer. The upper chamber of the pendulum is a cylinder of an inch or more in diameter. By change of atmospheric pressure the mercury in the pendulum is displaced from the bottom to the top, and *vice versa.* The rate of the clock is accelerated or retarded in proportion to the displacement of the mercury. (*Quarterly Journal Met. Soc.* Vol. III. p. 352.) (Fig. 20.) *Exhibited by* W. F. STANLEY, F.R.Met.Soc.

68. **Sympiesometer,** by Adie of Edinburgh, 1830. *Exhibited by* R. J. LECKY, F.R.Met.Soc.

69. **Sympiesometer,** by W. Harris & Co., London. *Exhibited by the* KEW COMMITTEE.

70. **Sympiesometer.** (Fig. 21.) *Exhibited by* Messrs. NEGRETTI & ZAMBRA.

71. **New Form of Sympiesometer.**—In this instrument the reading is obtained by merely bringing the two liquid columns into level (by turning the milled head at side), when the reading is at once shown by the arrow point, and the observation remains recorded. The observer has nothing whatever to do with any compensation for temperature. In the old form of Sympiesometer four operations were necessary in taking a reading:—1st, to read the thermometer; 2nd, to set the sliding scale to correspond; 3rd, to read the barometer scale; and 4th, to record the observation on the disc. In this instrument but one operation is necessary, and that of the simplest nature and self-recording. In the Sympiesometer there are four scales, including the recorder. In this instrument there is but one scale. A rise or fall is seen at a glance by the mercury standing higher or lower than the liquid in the other tube. The compensation is effected by the fact that the air-bulb is so proportioned that the rise and fall of the barometer and thermometer are exactly equal for changes of temperature. Any difference of level between them, therefore, is due to a change in barometric pressure. *Exhibited by* L. P. CASELLA, F.R.Met.Soc.

72. **Hicks's Flexible Barometer.** (Fig. 22.) *Exhibited by* J. J. HICKS, F.R.Met.Soc.

73. **Lowne's Handy Weather Glass,** indicating both pressure and temperature. *Exhibited by the* METEOROLOGICAL COUNCIL.

74. **Ronketti's Thermo-Barometer.** *Exhibited by the* METEOROLOGICAL COUNCIL.

75. **Differential Barometer.**—This consists of a tube with fine bore, at one end of which is cemented a thin corrugated metal chamber, at the other end is a glass bulb. The metal chamber is filled with a coloured fluid, which is pressed upwards in the tube as the weight of the air increases; the upper or glass bulb is hermetically sealed, and corrects the effect of temperature. There is an adjustment by which it may be set to agree with a standard barometer. The instrument is portable in any position. *Exhibited by* R. H. C. WILSON.

ANEROIDS.

52. **Skeleton Aneroid,** showing the various working parts. (Fig. 15.)
Exhibited by L. P. Casella, F.R.Met.Soc.

53. **Aneroid, with Altitude Scale.**
Exhibited by Messrs. Negretti and Zambra.

54. **Aneroid (Compensated)** with enlarged altitude scale.
Exhibited by L. P. Casella, F.R.Met.Soc.

55. **Negretti and Zambra's Pocket Watch Aneroid.**—This instrument, which is the size of an ordinary watch, indicates heights to 20,000 feet. (Fig. 16.) *Exhibited by* Messrs. Negretti and Zambra.

56. **Aneroid,** by Dent.—A specimen of the aneroids supplied to H.M. ships previous to 1854. It has never been repaired.
Exhibited by the Meteorological Council.

57. **Aneroid,** by Negretti and Zambra, compensated. The pattern as supplied to H.M. ships. *Exhibited by the* Meteorological Council.

58. **Stanley's Surveying Aneroid.**—This is an ordinary aneroid with altitude scale. The index is read upon the same plane as the divided circle, by a line, which is placed upon a small aluminium plate at the end of the index hand. The instrument has a magnifier, carried by a ring so as to be brought over the index at any position. (Fig. 17.)
Exhibited by W. F. Stanley, F.R.Met.Soc.

59. **Field's Engineering Aneroid.**—In this instrument the scale of altitudes is movable, but instead of being shifted at pleasure, according to the position of the index, it is moved into certain fixed positions according to the temperature of the air, so that the shifting of the scale answers the same purpose as if the original scale were altered to suit the various temperatures of the air. The outer movable scale is graduated in feet for altitudes, and the graduation is laid down by fixing the zero opposite 31·0 ins. This is the normal position of the scale, and it is correct for a temperature of 50°. For temperatures below 50° the zero of the scale is moved below 31·0 ins.; and for temperatures above 50° it is moved above 31·0 ins. In order to insure the altitude scale not being shifted after it has once been set in its proper position there is a contrivance for locking it in the various positions. The altitudes are in all cases determined by taking two readings, one at each station, and then subtracting the reading at the lower station from that of the upper. (*Quarterly Journal Met. Soc.* Vol. II. p. 10.) (Fig. 18.)
Exhibited by L. P. Casella, F.R.Met.Soc.

60. **Richard's Self-recording Aneroid.**—This instrument consists of a series of eight vacuum boxes, by which the effects of the atmospheric pressure are increased and transmitted by a system of levers to an arm carrying a pen. This pen, of a special form, contains an ink mixed with glycerine, and marks the curve of atmospheric pressure on the paper round the cylinder. The cylinder revolves once in seven days, so that the paper contains a week's record. (Fig. 19.)
Exhibited by Messrs. Richard Frères.

61. **Self-registering Aneroid,** with max. and min. indexes.
Exhibited by L. P. Casella, F.R.Met.Soc.

62. **Barometer Dial 6 ft. in diameter,** the hand of which is kept in its true position by a single aneroid vacuum box.
Exhibited by Messrs. Lund and Blockley.

DIAGRAMS, PHOTOGRAPHS, &c.

88. **Drawings of various forms of Old Barometers,** including those of Torricelli, Sturmius, and Huyghens.
Exhibited by the ROYAL METEOROLOGICAL SOCIETY.

89. **Barometer with overfall,** constructed for Lavoisier. (Photograph.)
Exhibited by G. J. SYMONS, F.R.S.

90. **Krueger's Compensated Barometer.**—The upper part of the tube is enlarged to a retort, the volume of which corresponds to a length of one or two metres of the tube. A quantity of air is introduced into the tube, the pressure of which is equal to about 34·5 mm. mercury. The scale is divided with due regard to the effect of that depression. The zero having been adjusted by comparison with a standard barometer, the reading will immediately give the height reduced to normal temperature of mercury and scale. (Photograph.)
Exhibited by G. J. SYMONS, F.R.S.

91. **Barometer of a New System of Construction,** by W. Gloukhoff, St. Petersburg. (Photograph.) *Exhibited by* G. J. SYMONS, F.R.S.

92. **Christensen's Electric Storm Signal Barometer.** This instrument is constructed in order to give notice of any rapid fall of the barometer. It is a siphon barometer, and as the mercury rises in the short leg of the tube, it comes in contact with an adjustable metallic point, and by completing an electric circuit sets an electric bell ringing. (Specification.)
Exhibited by the ROYAL METEOROLOGICAL SOCIETY.

93. **Changeux's Barograph.** Description and sketch, 1781.
Exhibited by the ROYAL METEOROLOGICAL SOCIETY.

94. **Jordan's Photographic Barograph.** The scale of the barometer is perforated as usual to admit a portion of the tube, and the prepared paper is made to revolve as close as possible to the glass, in order to obtain a well-defined image. The cylinder is made to revolve on its axis once in forty-eight hours, and the paper is divided into forty-eight parts by vertical lines, which are figured in correspondence with the hour at which they respectively arrive at the barometer tube. (*Report of the Royal Cornwall Polytechnic Society*, 1838.) (Sketch.)
Exhibited by the ROYAL METEOROLOGICAL SOCIETY.

95. **Brooke's Photographic Barograph.** The barometer is a large siphon tube, the bore of the upper and lower extremities being about 1·1 in. A glass float is partly supported by a counterpoise acting on a light lever, leaving a definite part of its weight to be supported by the mercury. The lever carries at its other end a vertical plate of opaque mica, having a small aperture, whose distance from the fulcrum is about eight times that of the point of connection with the float, and whose vertical movement is therefore about four times that of the ordinary barometric column. The light of a gas lamp, passing through the aperture and falling on a cylindrical lens, forms a spot of light on the photographic paper wrapped round a cylinder placed vertically, and moved round its axis by a clock fixed with its face horizontal. (Photograph.)
Exhibited by G. J. SYMONS, F.R.S.

96. **Ronald's Photographic Barograph.** Description and sketch of Ronald's photographic self-registering meteorological instruments. (*Philosophical Transactions*, 1847.) *Exhibited by* G. J. SYMONS, F.R.S.

97. **Kew Photographic Barograph.** (Sketch.) (See *Report of the Meteorological Committee to the Royal Society*, 1867.)
Exhibited by the METEOROLOGICAL COUNCIL.

98. **King's Barograph.**—The barometer tube is 3 ins. in internal diameter and, guided by friction wheels, floats freely in a fixed cistern. The top of the tube is fastened to a chain, which passes over a grooved wheel turning on finely adjusted friction rollers. The other end of the chain supports a frame, which carries the recording pencil. The frame is suitably weighted and guided, and faces the cylinder around which is wrapped the tracing paper, and which rotates once in twenty-four hours by the movement of a clock. The instrument is so arranged that for 1 in. change in the mercurial column the pencil is moved over 5 ins. of the paper. (Large Drawing.)
Exhibited by L. P. CASELLA, F.R.Met.Soc.

99. **Kreil's Barograph.**—This instrument was employed at the Kew Observatory in 1845 for the purpose of registering automatically the height of the barometer. It consists of a siphon barometer, having a float resting upon the surface of the mercury in the open end of the tube. Immediately above the tube a lever is fixed horizontally, and a cord, wrapped round the sector on the short arm, passes down and is attached to the float. The other end of the lever carries an ordinary pencil, which, being struck every five minutes by a hammer moved by a clock, makes a dot upon a sheet of paper fixed to a frame drawn in front of it by clockwork. (Photograph.)
Exhibited by G. J. SYMONS, F.R.S.

100. **Theorell's Meteorograph.**—Account and Sketch of Theorell's Printing Meteorograph. (*Nova Acta Reg. Soc. Upsala*, 1868.)
Exhibited by G. J. SYMONS, F.R.S.

101. **Russell's Electrical Barograph.**—The barometer tube is fixed, but the cistern (which is a small one) floats in a vessel of mercury. The pen is attached to a rectangular framework, which is drawn backwards and forwards once a minute in front of the paper. On electrical contact being made between a lever attached to the cistern and the side of a wire triangle attached to the pen frame, the pen is pressed against the paper, and thus the record is made. (Diagram.)
Exhibited by the ROYAL METEOROLOGICAL SOCIETY.

102. **Van Rysselberghe's Meteorograph.**—This instrument engraves automatically on metal the ordinates of the meteorographical curves, thus furnishing a plate graduated by the instrument itself, from which as many copies as required may be struck off. A single burin, put in motion by an electro-magnet, engraves successively on one metallic plate the elements of all the curves. The indicating instruments may be at any distance from the registering apparatus. (Sketch.)
Exhibited by the ROYAL METEOROLOGICAL SOCIETY.

103. **Draper's Barograph.**—In this instrument the tube is 36 ins. in length, the upper portion being of larger diameter than the lower; it is held firmly in a fixed position, and filled with mercury; its lower open end dips into a reservoir containing the same metal. This reservoir is suspended on two spiral steel springs, and has freedom of motion up and down. When the pressure of the atmosphere diminishes, a portion of the mercury flows out of the tube into the reservoir; this becoming heavier, stretches the steel springs, causing the ink pencil fastened to them to mark downwards. If the pressure increases, the reverse movement takes place. The ink pencil makes its mark on a ruled paper register, carried at the rate of half an inch per hour from right to left by a clock. There is a third steel spring of the same length and strength as those on the reservoir, stretched by a weight to a distance equivalent to 30 ins. on the barometer scale. The object of this spring is to give the correction for temperature for those sustaining the reservoir. (Sketch.)
Exhibited by the ROYAL METEOROLOGICAL SOCIETY.

104. **Raymond's Amateur's Barograph.**—Illustration and description in *La Nature*, December 19th, 1885. *Exhibited by the* KEW COMMITTEE.

105. **Royal Society Water Barometer.**—Description and illustration of the water barometer erected in the Hall of the Royal Society, Somerset House, 1830, by Prof. J. F. Daniell, F.R.S. (*Philosophical Transactions*, 1832.) *Exhibited by the* ROYAL METEOROLOGICAL SOCIETY.

106. **Bird's Water Barometer.**—Account and sketch of the water barometer constructed and erected by A. Bird of Birmingham. (*Philosophical Magazine*, 1865.) *Exhibited by* G. J. SYMONS, F.R.S.

107. **Kew Standard Barometer.**—Account of the construction of a standard barometer, and description of the apparatus and processes employed in the verification of barometers at the Kew Observatory, by J. Welsh. (*Philosophical Transactions*, 1856.) *Exhibited by the* KEW COMMITTEE.

108. **Loseby's Maury Barometer.**—This instrument is much like an ordinary aneroid in appearance, and contains a vacuum box of similar construction. The rise and fall of the box is measured by a fine micrometer screw, which is turned by the observer, either through an aperture in the glass, or by a milled head in the pendant of the case. This micrometer screw is placed immediately over a steel stud, which is attached to the centre of the vacuum box, and projects above it. Between this stud and the end of the micrometer screw a pivoted drop-piece is placed, which falls the instant the screw is unturned sufficiently to remove the bearing points of the screw, stud, and drop-piece out of contact with each other. The drop-piece is pivoted by a screw into a frame attached to the top of the vacuum box, and is made to fall either by its own gravity or by a suitable spring, and an aperture is left in the dial to enable its fall to be seen. The divisions on the dial are continued round in a spiral. The hand, which is fixed to the micrometer screw, and turns round with it, extends across all the divisions; and a small index dial, visible through an aperture in the large one, indicates to which spiral the hand is pointing. All three figures on the small dial are shown at once, to avoid the difficulty, which sometimes arises with a small opening, of having only the unintelligible parts of two figures visible. The figure nearest the middle is the one that should be read. (Illustration and Photograph.)
Exhibited by the ROYAL METEOROLOGICAL SOCIETY.

109. **Bourdon's Counterpoised Barometer.**—(Photograph.)
Exhibited by G. J. SYMONS, F.R.S.

110. **Aneroid, on Weilenmann System,** by Goldschmid, of Zurich. (Photograph.)
Exhibited by G. J. SYMONS, F.R.S.

111. **Barogram from Royal Observatory, Greenwich,** for May 13th and 14th, 1883. *Exhibited by the* ASTRONOMER ROYAL.

112. **Barograms from the Kew and Falmouth Observatories,** January 13th, 1886, showing sudden oscillation during the passage of a squall.
Exhibited by the METEOROLOGICAL COUNCIL.

113. **Curves from a Richard Barograph** from March 12th, 1885, to March 15th, 1886, mounted in album. *Exhibited by* F. C. BAYARD, F.R.Met.Soc.

114. **Curves from a Richard Barograph,** showing instances of upward move of curve immediately before squalls and heavy rain at Bedford, May 11th, 1885, to February 8th, 1886.
Exhibited by Lieut.-Col. C. K. BROOKE, F.R.Met.Soc.

115. **Curve from Whitehouse's Micro-Barograph.**—May 8th and October 1st, 1871. (See *Proceedings of the Royal Society*, Vol. XIX. p. 491.)
Exhibited by the METEOROLOGICAL COUNCIL.

116. **Primrose's Electric Meteorological Scale Reader.** This is an instrument to transmit by one wire, continuously or at intervals as desired, readings of a distant instrument. It is intended to register from mountain tops or captive balloons. (Diagram.)
Exhibited by G. R. PRIMROSE.

117. **Latham's Earth Hygrometer.**—This records the hygrometric condition of ground as compared with the air. It consists of three perforated cylinders, each filled with earth, one being immediately below the surface of the ground, the second one foot below it, and the third suspended in the air. Each of the earth cylinders is suspended from the end of a lever. On the opposite side of each lever there is a counterweight. Each cylinder acts independently, and records its observations upon a cylinder driven by clockwork. There is also an index upon each machine which shows at a glance the percentage of moisture which the earth in the cylinders contains. (Drawing.)
Exhibited by BALDWIN LATHAM, F.R.Met.Soc.

118. **Five years' Graphic Record of Sunshine, 1881-5,** taken with Stokes' zodiacal sunshine recorder, at Mr. Dymond's Observatory, Aspley Guise, Bedfordshire, showing the comparative monthly duration of sunshine year by year. *Exhibited by* R. J. LECKY, F.R.Met.Soc.

119. **The Chromatics of the Sky.**—Coloured drawings of clouds and other atmospheric phenomena taken from nature, 1885-1886, with the object of assisting in making weather forecasts. (Fourth series.)
Exhibited by J. S. DYASON, F.R.Met.Soc.

120. **Photograph of a Sun Spot** and adjacent portion of the solar surface, taken by Mons. Janssen, at the Meudon Observatory, June 22nd, 1885.
Exhibited by R. H. SCOTT, F.R.S.

WILLIAM ELLIS, F.R.A.S., *President.*
G. J. SYMONS, F.R.S. } *Secretaries.*
JOHN W. TRIPE, M.D. }
WILLIAM MARRIOTT, *Assistant Secretary.*

PROCEEDINGS AT THE MEETINGS OF THE SOCIETY.

MARCH 17TH, 1886.

Ordinary Meeting.

WILLIAM ELLIS, F.R.A.S., President, in the Chair.

WILLIAM DERING ADDISON, Riga, Russia;
ARTHUR WILLIAM CLAYDEN, M.A., F.G.S., Bath College, Bath;
THOMAS BARRINGTON MOODY, Navigating-Lieut. R.N., Waverley, Westcombe Park, Blackheath, S.E.; and
Dr. WILLIAM SCHLICH, Inspector-General of Forests to the Government of India, Cooper's Hill College, Staines;
were balloted for and duly elected Fellows of the Society.

The following Paper was read, viz.:—

"BRIEF HISTORICAL ACCOUNT OF THE BAROMETER." By WILLIAM ELLIS, F.R.A.S., President. (p. 131.)

On the motion of Mr. EATON, seconded by Mr. LAUGHTON, the thanks of the Society were given to the PRESIDENT for his Paper.

On the motion of Dr. MARCET, seconded by Mr. CHATTERTON, the thanks of the Society were given to the Exhibitors for the loan of their Instruments.

The Meeting was then adjourned in order to afford the Fellows an opportunity of examining the Exhibition of Barometers which was held in the Library of the Institution of Civil Engineers. The List of Exhibits will be found on p. 200.

APRIL 21ST, 1886.

Ordinary Meeting.

WILLIAM ELLIS, F.R.A.S., President, in the Chair.

LAWRENCE JOSEPH PETRE, Coptfold Hall, Ingatestone, Essex; a
GEORGE BAYNES WETHERALL, The Aucubas, St. George's Square,
were balloted for and duly elected Fellows of the Society.

The following Papers were read:—

"NOTE ON THE PROBABILITY OF WEATHER SEQUENCE." By I
C. K. BROOKE, F.R.Met.Soc. (p. 172.)

"ACCOUNT OF THE CYCLONE OF JUNE 3rd, 1885, IN THE ARABIA
CAPT. MAURICE T. MOSS. (p. 174.)

"RESULTS OF SOLAR RADIATION OBSERVATIONS IN THE NEIGHB
BIRMINGHAM, 1875-1884." By RUPERT T. SMITH, F.R.Met.Soc.,
(p. 180.)

"THE CLIMATE OF KILLARNEY." By the VEN. ARCHDEACON W
F.R.Met.Soc. (p. 193.)

"RESULTS OF METEOROLOGICAL OBSERVATIONS MADE IN SELAN
STATES, 1879-1884." By A. W. SINCLAIR, L.R.C.P. (p. 197.)

CORRESPONDENCE AND NOTES.

METEOROLOGY OF THE STRAITS SETTLEMENTS.

DR. T. I. ROWELL, in his Meteorological Report for the year 18
results of the observations taken at Singapore, Penang, Province V
Malacca. These, together with the results from Singapore from
furnish valuable and interesting data for the Straits Settlements.

The following are the mean results for 1885:—

Station.	Barometer (reduced to 32°)[1]	Temperature. Max.	Min.	Mean.[2]	Highest.	Date.	Lowest.	Date.
	ins.	°	°	°	°	°	°	°
Kampong Kerbau Obsy, Singapore ..	29·889	87·2	72·3	81·7	92·0	May 24	63·4	Feb. 1
Penang	·972	89·3	74·8	82·7	96·5	June 14	70·0	Jan. 1
Province Wellesley ..	·833	91·4	72·5	83·5	98·0	Jan. 9	65·5	Feb. 2
Malacca	29·860	88·7	73·9	82·3	96·0	June 18	69·0	Jan. 1

[1] The height of the barometer above sea-level is not stated.
[2] These are the means of observations at 9 a.m., 3 p.m., and 9 p.m.

The total number of rainfall stations in the Straits is twent
following are the totals for the year 1885 from such stations as fur
returns:—

SINGAPORE.	ins.	PROVINCE WELLESLEY.	ins.
P. & O. Co.'s Wharf ...	64·51	Butterworth	114·52
General Hospital... ...	80·55	Bertram	87·94
Kandang Kerbau Hospital	71·01	Bukit Minyak	96·99
Serangoong Road... ...	66·10	Sungei Bakup	118·81
Thompson Road	61·75	Pulau Jerajah	112·19
Tanglin	67·43	MALACCA.	
St. John's Island... ...	59·91	Town	77·74
PENANG.		Durian Dahun	71·03
Fort Cornwallis	86·87	Kĕsang	54·37
Central Prison	107·15		
Government Hill... ...	138·41		

The following are the mean results from Singapore, 1870-85:—

Year.	Barometer (reduced to 32°)	Temperature.	Rainfall.	No. of Rainy Days.
	ins.	°	ins.	
1870	29·802	80·7	123·24	209
1871	·836	80·8	109·45	195
1872	·824	81·5	75·30	161
1873	·829	81·3	85·60	166
1874	·879	80·7	87·05	178
1875	·884	81·0	93·96	166
1876	·885	81·1	89·91	163
1877	·903	82·1	58·37	119
1878	·864	82·0	103·16	170
1879	·857	80·5	116·14	181
1880	·863	81·0	111·08	189
1881	·874	81·6	94·00	144
1882	·863	81·7	88·16	158
1883	·878	81·3	70·14	141
1884	·890	81·1	80·13	146
1885	29·889	81·7	67·32	134

Mr. H. T. BURLS, F.R.Met.Soc., of Sarawak, has forwarded the following data for Kutching, which he has copied from Papers and Records kept by the Sarawak Treasurer.

TEMPERATURE AT KUTCHING 1876-1878.

Month.	1876.		1877.		1878.	
	Max.	Min.	Max.	Min.	Max.	Min.
	°	°	°	°	°	°
January[1]	86	69	86	72	88	73
February	86	71	87	69	86	74
March	90	73	89	72	89	71
April	92	73	88	72	89	71
May	90·5	74	91	73	89	74
June	89	73·5	90	73	89	74
July	89	72	91	72	88	74
August	89	73	93	71	89	73
September	90	71	93	69	90	73
October	89	73	89	70	90	72
November	87	72	90	71	90	71
December	88	70	89	72	90	74
Year	88·8	72·0	89·7	71·3	88·9	72·8

[1] In January 1876 the means apply only for the period from the 15th to 30th.

RAINFALL AT KUTCHING 1876-1879.

Month.	1876. Amount.	1876. No. of Rainy days.	1877. Amount.	1877. No. of Rainy days.	1878. Amount.	1878. No. of Rainy days.	1879. Amount.	1879. No. of Rainy days.
	ins.		ins.		ins.		ins.	
January[1]	16·53 ?	14?	38·85	31	25·93	28	34·39	28
February	38·15	16	21·66	16	26·46	23	20·28	22
March	5·77	12	17·23	22	25·11	22	23·85	27
April	3·90	10	11·13	20	5·82	22	11·14	16
May	6·97	14	13·15	9	6·22	..	11·72	18
June	5·63	14	9·66	14	12·56	..	6·70	14
July	6·06	11	7·40	16	12·87	14	7·32	13
August	16·18	18	0·66	3	11·75	19	14·93	22
September	3·65	10	7·57	11	11·05	19	5·42	18
October	15·45	24	4·88	15	6·95	12	17·01	24
November	15·53	23	12·32	24	18·09	24	13·31	25
December	25·91	27	13·70	18	14·67	13	22·21	24
Year	159·73?	193?	158·21	199	177·48	..	188·28	251

[1] In January 1876 the rainfall is only for the 16 days 15th to 30th.

IN February 1876 15·20 ins., and in January 1878 9·12 ins. of rain fell on one day.

THE TORNADO IN MADRID ON MAY 12th, 1886. Communicated by W. F. STANLEY, F.R.Met.Soc., F.G.S.

On the evening of May 12th a most violent and destructive tornado swept over Madrid, causing great loss of life and destruction of property. The following account has been compiled chiefly from a Paper by Mons. A. F. Nogués in *La Nature* of June 5th.

From the evening of the 10th to the 12th the sky of Madrid was covered with a slight kind of fog or transparent cloud of a reddish colour, through which the stars shone. On the horizon there was a band of cloud of a sombre tint. The temperature was hot, even to suffocation. At last a very remarkable phenomenon was observed by many persons. Through the fog, at an altitude of about 3,000 feet, an immense spiral was seen, illuminated by the sun, formed by a mass of air in motion drawing cloud particles into its vortex.

At the commencement of the storm the clouds drifted from the South and South-west; the vane, however, which at first indicated South-east, turned to North-north-east; and during a great part of the storm it stood at due North. The lower currents were therefore evidently moving in a contrary direction to the upper currents. During the afternoon the sky assumed a stormy appearance; and at 6.25 p.m. a thunderstorm occurred accompanied with torrential rain and hail. At 6.50 p.m. the wind backed to North-west and then to West, and a little before 7 p.m. to South-west. The wind increased in force in proportion to the rapidity of the change in direction, and culminated in a whirlwind which attained its greatest intensity between 7.1 and 7.6 p.m., during which time its violence surpassed anything that had ever occurred before in Madrid. In this short space of time the destruction of property was immense.

The barometer, which had fallen from 29·64 ins. at 1 p.m. to 29·35 ins. at 6 p.m., oscillated in a violent manner. In two instances the sudden depressions were almost instantaneous. At 6.30 p.m. a torrential rain deluged the streets, which with the lightning, thunder and hail, rendered the scene frightful. Buildings were thrown down or destroyed, the public lamps were broken off, trees were

rn up and shattered, and large and heavy objects were transported to great istances by the violence of the wind. Railway carriages, tram cars, and large ule carts were upset, and people knocked down in the streets.

The storm was repeated with less violence at 8 and 11 p.m. From an examination of the ruins, the direction of the tornado could be easily traced. The oint of greatest intensity was between the Atocha gate and the Retiro Gardens, r in this space the Botanical Garden has almost entirely disappeared, whereas the Rue de Tragineros but few trees were uprooted. The destructive effect of e tornado appeared to cease at the Cybèle fountain.

The damage was very great, twenty-four persons were killed, seventy-eight riously, and 104 slightly injured. About fifty-four houses were destroyed, and ,000 trees and 600 lamps thrown down.

HE METEOROLOGY OF THE SUN AND ITS SYSTEM. By Professor K. W. ZENGER. Memoir of 281 pp. 4to., with 5 Cuts and 4 Plates. Brief Notice prepared at the request of the President and Council of the Royal Meteorological Society, by G. M. WHIPPLE, B.Sc., F.R.Met.Soc.

HE author fitted an apparatus to a With-Browning reflector telescope, which nabled him to take pictures of the sun. He soon found that, in spite of l his precautions, certain white objects appeared on his plate surrounding e sun's disc. These he at first attributed to photographic irradiation. his cause, however, would produce a concentric ring round the disc, an ppearance which these objects never possessed.

The white rings were often decidedly elliptic in form, or appeared projected s streaks out from the periphery of the sun's image. The more the mirror perture was reduced the more ill-defined and misty the margins of these ings became. Their colour varied from a greyish-white to snow-white. rof. Zenger thought they might perhaps be the most luminous parts of the hromosphere and solar corona, showing themselves as whitish rings in spite f the under-exposure of the plates in the order of their relative luminous ntensity.

With the view of proving that these appearances were not due to instrumental defects, Prof. Zenger employed various systems of lenses and apparatus. He found eventually that a system of Steinheil's lenses gave not only sharper ictures of the rings, but also afforded a mass of detail in them, in which night be recognised spiral forms of various gradations of tint from grey to lazzling white. These observations were first made during an exceptionally evere storm on March 5th, 1875, when the elliptical rings appeared of a rilliant white colour, although the sky was at the time perfectly clear and ut a single little cloud moved rapidly across it.

These appearances were again observed the same day, the rings being imilarly shaped, although a different apparatus was employed. There seemed hen no doubt that these circular or elliptical white rings were not to be ttributed to under-exposure of faintly luminous parts of the solar surroundings, the chromosphere or the corona, but resulted from the powerful bsorption of actinic rays in the vicinity of the sun's image. These expanded white rings, which often extended to five times the diameter of the solar

image, were termed by the author "absorption zones," and were considered by him to have their origin in the immediate neighbourhood of the sun.

With a view of rendering the collodion he employed in the photography equally sensitive to actinic and non-actinic rays, to the yellow and red of the chromosphere and the yellow-green rays of the corona, the author employed chlorophyll in his emulsion, which was prepared by Cooper's process.

Having given in detail the methods of preparing, exposing and developing his plates, Prof. Zenger goes on to state that he always takes five sun pictures every day on one plate—one central, the others one in each corner. In this manner he considers he proves that the white spots are not solar phenomena, and arrives at the following conclusions:—

1. That pictures taken only at intervals of one minute show changes in the figure and position of the absorption zones, although there is a corresponding maintenance of their general forms.

2. After the fifth exposure, or even if an interval of five minutes is allowed to lapse between them, these appearances often become entirely modified in form, *e.g.* instead of circular or elliptic they become streaked or even reversed, at other times they partially or entirely disappear.

3. These absorption zones often extend to the margin of, or even over, the sun's disc itself, so that instead of it coming out wholly or partially black in the picture, it looks grey or whitish-grey.

Prof. Zenger has also discovered that the maximum of evolution of these absorption phenomena has a period throughout the whole year of from 10 to 13 days, and they are strongest when violent storms, thunderstorms or magnetic disturbances prevail on the earth, frequently being observed 24 or more hours before the disturbance of the atmospheric, electrical or magnetic equilibrium of the place of observation takes place.

The author states that the observations, which have now been made daily since 1874, indicate not only a definite periodicity in the appearances of absorption images in the sun's pictures, but the existence of a relation between weather phenomena and certain appearances which are invisible both to the naked as well as to the assisted eye. By the absorption of the actinic active rays previously present in the one atmosphere or external to it, the prepared plate renders them visible, although previously neither telescope nor spectroscope afforded any indications of their presence. Whether or not these appearances have their seat in the earth's atmosphere, or in space between the sun and the earth, can only be decided when experiments are made simultaneously and regularly at places so far distant from each other that the effect of parallax will be visible and measurable. Should the latter be the case their origin must be sought in the earth's atmosphere or in space immediately adjacent to it. If otherwise, there must be some source of solar influence hitherto unobserved. The author goes on to state that the aim of his little work is, therefore, to call the attention of meteorologists and physicists to these remarkable appearances and their explanation, and to show how by the simplicity of the photographic operations amateurs might easily prove by means of heliophotography both the periodical appearance of

these absorption phenomena as well as their connection with great disturbances of the earth's atmosphere.

The Section I. of the paper is entitled On the Results of Heliophotographic Observations, 1874-1884, and gives a general review of the various phenomena Prof. Zenger has observed, and offers numerous suggestions as to the possible causes giving rise to them.

In Section II. of his work the author discusses (*a*) the periodicity of solar outbreaks and their influence on the planets; and (*b*) the solar activity, with its corresponding magnetic disturbances and aurora during 1882, compared with the evidence afforded by solar photography.

Section III. treats of the periodicity of great barometric depressions (cyclones, typhoons and storms), leading up to the following conclusions, viz. That (1.) all great terrestrial storms have their origin in the sun. (2.) The electrical discharges from the solar body into interplanetary space are the originating cause of the formation of cyclonic motion in the same; and (3.) These discharges, proceeding more particularly from the equatorial regions of the sun, eventually influence the planets, if their dimensions are sufficiently great, and therefore all the planets are affected in a similar manner to the earth by them.

In Section IV. Prof. Zenger traces the connection between solar disturbance phenomena, and seismological and volcanic effects, whilst in Section V. the dependence of meteoric and star showers upon the rotation period of the sun is demonstrated.

In Section VI. he treats of the meteorology of the earth and its connection with the sun's rotation and the passage of meteorites through space in its immediate vicinity, winding up with a strong appeal for the establishment of numerous inexpensive helio-photographic observatories.

Section VII. is entitled, The Meteorology of the Planetary System in general. Section VIII. The Meteorology of the Sun's Surface and the endogenous Disturbances of the Sun.

In Section IX. Prof. Zenger discusses the relation between the rotation of the sun and the general movement in the solar system; whilst finally, in Section X., he investigates the relation of disturbances in the sun to the disturbances of the electric and magnetic equilibrium of the earth and of the force of gravity, concluding his interesting work of 231 pp. with these words: —"Let me briefly state as a *resumé* of all the foregoing the following conclusions, all meteorological phenomena, all endogenous disturbances, in addition to the movements of the solar system, the phenomenon of universal gravitation, and all manifestations of electrical and magnetic forces, are to be referred back to one single source of power, which has its seat not only in the sun but also in the most minute particle of our own enormous solar system and the other innumerable solar systems which exist. Its energy acts according to the same universal fundamental law, whose action is evidenced in the various forms of electric and magnetic force from which all the remaining forms may be easily derived, whether they be sound, light, heat, or the action of gravity."

[NOTE.—A close examination of the Kew Solar Photographs, taken almost daily for more than ten years, has not revealed the presence in any of them of the appearances described by Prof. Zenger. Halo-like forms, due to irradiation or halation, have been easily produced as an experiment, by over-exposing a prepared plate, even when the luminous source was but a candle. These are due to the glass plate supporting the sensitive surface; and it has been suggested to Prof. Zenger that he should employ paper or films in his future experiments in order to avoid this source of uncertainty in his results.

G.M.W.]

RECENT PUBLICATIONS.

AMERICAN JOURNAL OF SCIENCE, Vol. XXX., December 1885. 8vo.

Contains:—The condensing Hygrometer and the Psychrometer, by H. A. Hazen (17 pp.). The author says:—"It would seem that, if a nearly uniform law can be established between the indications of these two instruments, under all conditions of temperature, dryness, motion and other conditions of the air, certainly we can depend upon the indications of each by itself at all times. It is the object of this paper to indicate a practical method of using these instruments, to contribute towards the establishment of a law controlling them, and to show what accuracy may be attained by either of them."

AMERICAN METEOROLOGICAL JOURNAL. A Monthly Review of Meteorology, Medical Climatology, and Geography. April-June 1886. Vol. II. No. 12,—Vol. III. No. 3. 8vo.

The original articles are:—The Mountain Meteorological Stations of Europe, by A. L. Rotch (19 pp.). The author in these Nos. describes the observatories on (1) the Puy de Dôme, 4,800 feet above the sea; (2) the Pic du Midi de Bigorre, 9,380 feet; and (3) Ben Nevis, 4,407 feet.—Observations on the Sun-glow and related phenomena (Part II.), by G. H. Stone (7 pp.).—Local Storms in Oregon and Washington, by M. W. Harrington (4 pp.).—The Causes of Anti-cyclonic Cold in Winter, by W. R. Dewey (8 pp.). The author thinks that it is conclusively shown that cases of abnormal temperature on mountain tops and at lower stations in anticyclones can be explained by the theory brought forward by Dr. Hann, that the abnormality is due to an excess of the cooling by radiation over the warming by insolation and the compression in a slowly descending mass of air.—"Three Ice-Storms," by F. V. Pike (7 pp.).—Foreign Studies of Thunder-storms, by W. M. Davis (18 pp.).—Rain-Gauge Investigations, by E. B. Weston (3 pp.).—Thermometer Exposure, by H. A. Hazen (10 pp.).

ANALELE INSTITUTULUI METEOROLOGIC AL ROMANIEI DE STEFAN C. HEPITES, Directoral. 1885. Tom. 1. 4to. 1886. CXXXVIII. + 367 pp.

This is the first Vol. of the *Analele* of the Roumanian Meteorological Institute, which was established in July 1883. The present Vol. is divided into three parts:—1. Annual report on the proceedings of the Institute; 2. Description and instructions for the use of meteorological instruments, with numerous engravings; and 3. Meteorological observations made at Bucharest in 1885.

ANNALI DELL' UFFICIO CENTRALE DI METEOROLOGIA ITALIANA. Serie II., Vol. V. Parts I.-III., 1883. 4to. 1885.

Part I. consists of 937 pp., and contains papers on meteorological and magnetical subjects, among which may be mentioned:—Appendice alla Memoria 'Sulla Distribuzione della Pioggia in Italia,' per Prof. E. Millosevich (134 pp.).—Sulla ipsometria barometrica, per Dr. A. Lugli (24 pp.).—Sulla variazione media della tensione del vapore acqueo atmosferico in Italia, secondo la latitudine e

l' altezza, per Dr. A. Lugli (30 pp.).—Osservazioni dei temporali raccolte nel 1881 e relativo studio, del Dr. C. Ferrari (322 pp. and 36 plates).—Sui temporali osservati nell' Italia superiore durante l' anno 1879, per E. Pini (193 pp. and 15 plates).

Part II. (735 pp.) contains the results of observations made at 125 stations in Italy during the year 1883.

Part III. (207 pp.) in addition to other papers contains the following:—Meteorologia Solare, per P. Tacchini (58 pp. and 2 plates).—Distribuzione della temperatura e pioggia per decadi nel 1883 (9 pp.).

ANNUAIRE DE LA SOCIÉTÉ MÉTÉOROLOGIQUE DE FRANCE. 34me Année. 1886. February-April. 4to.

The principal papers are:—Expériences relatives aux courants ascendants et descendants de l'atmosphère, par M. Garrigou-Lagrange (3 pp.).—Nouveau baromètre enregistreur à mercure, par A. Redier (3 pp.).—Hauteurs de pluie à Vendôme en 35 ans, 1851-1885.—Le cyclone du 3 juin 1885 à Aden et la perte du "Renard," par M. Millot (5 pp.). This is an account of the same storm as is described by Capt. M. T. Moss on page 174 of the present No. of the *Quarterly Journal*.—Sur les tornades, par M. Bellamy (3 pp.).—Observatoire du Pic du Midi, M. C. X. Vaussemat (16 pp. and 6 plates).

AUS DEM ARCHIV DER DEUTSCHEN SEEWARTE. VII. Jahrgang, 1884. 4to. 1886.

In addition to the report on the work of the Deutsche Seewarte for the year 1884, and other papers, this contains a description of the central station at Hamburg, by Dr. Neumayer, which is illustrated by 29 plates and several woodcuts.

BOLETIN DE LA ACADEMIA NACIONAL DE CIENCIAS EN CORDOBA (República Argentina), December 1885. Tomo VIII. Entr. 2-3. 8vo.

Contains:—Observaciones Meteorológicas practicadas en Córdoba durante el año 1884 por Oscar Doering (88 pp.). The author gives the daily observations *in extenso*, which are made at 7 a.m., 2 p.m., and 9 p.m. The following are some of the principal results for the year:—Temperature: Mean 62°·3; Mean Max. 75°·9; Mean Min. 47°·5; Max. 103°·3 on January 18th; Minimum 18°·7 on June 22nd; Relative Humidity 65·9 per cent.; Rainfall 26·86 ins.

HANDBUCH DER AUSÜBENDEN WITTERUNGS-KUNDE, GESCHICHTE UND GEGENWARTIGER ZUSTAND DER WETTERPROGNOSE, von Dr. W. J. VAN BEBBER. Zwei Theile. 1 Theil. Geschichte der Wetterprognose. 1886. 8vo. 392 pp.

This work, which is only the first portion of the task Dr. van Bebber has laid out for himself to fulfil, is a fairly exhaustive treatise on all the efforts which have been made from the earliest periods to discover the agencies which produce weather, and to endeavour to foretell its course. The author discusses at great length the question of lunar influence, atmospheric tides, &c.; and concludes with a summary statement to the effect that those who profess to use the moon and its changes in forecasting are no better than astro-meteorologists. He admits, however, that for many years to come the public will hold to the moon as the great weather ruler. The sunspot theory is also treated very fully, and the author states that he believes that the existence of solar influence cannot be denied, but inasmuch as there are so many disturbing agencies, it is not possible to base predictions on it. The latter part of the book (100 pages) is taken up with the development of modern meteorology.

L'INCLINAISON DES VENTS. Un Anémomètre pour observer cette Inclinaison. Avec un Appendice sur les Courants verticaux dans les Cyclones. Deuxième Note. Par LE R. P. MARC DECHEVRENS, J.P., Directeur de l'Observatoire de Zi-Ka-Wei, près Chang-Hai, Chine. 4to. 1886. 48 pp.

M. Dechevrens brought out his Anemometer for recording the Inclination of the Wind in 1881. It was affected by the rain, snow, &c., and consequently did not work satisfactorily. The author attempted to obviate these inconveniences, and devised a better form of instrument, which he calls the "Clino-Anemometer."

Les Orages en Russie. Par Prof. A. Klossovsky. 8vo. 1886.

The author rejects Mohn's classification of thunderstorms into "heat" storms and "cyclonic" storms, and says that all of them are cyclonic, but arise under certain conditions of heat, humidity and pressure. In Russia all the thunderstorms have a tendency to appear in the south-east quadrant of the cyclone, this tendency being most marked in the spring and autumn, while in summer they may appear in all quadrants. They never occur with very high or very low barometers, but are most common between 755 mm. and 760 mm., and for Southern Russia they are much more frequent with depressions coming from the Mediterranean Sea or formed locally, than with those from the Atlantic. The conditions which the author considers to determine the existence of a thunderstorm, in addition to the presence of a depression, are a high temperature and an absence of fog or mist.

Lightning Conductors: Their History, Nature, and Mode of Application. By Richard Anderson, F.C.S. Third Edition. 1885. 8vo. xv. + 470 pp.

This contains, not only a history of the various methods that have been used, but also a practical exposition of the systems employed by the best authorities in various countries.

Meteorologische Zeitschrift. Herausgegeben von der öesterreichischen Gesellschaft für Meteorologie und der deutschen meteorologischen Gesellschaft. Redigirt von Dr. J. Hann und Dr. W. Köppen. Vol. III. 1886. April-June. 4to.

Contains:—Das Klima von Batavia, von J. Liznar (9 pp.). This is a notice of Dr. van der Stok's *Observations made at Batavia*, Vol. VI., which contains a summary of all the observations made during the seventeen years 1866-82. Herr Liznar is of opinion that for a tropical station ten years are quite sufficient to give really trustworthy means.—Einige Umformungen der Formel für barometrische Hohenmessungen zur Verwendung bei Reduction von Barometerständen, von Dr. P. Schreiber (5 pp.).—Die Untersuchungen von Dr. J. van Bebber über typische Witterungs-Erscheinungen, von Dr. W. Köppen (14 pp.). This is a notice which anticipates the second volume of Dr. van Bebber's book, which will be published in the course of a month or so.—Ueber Langley's Untersuchungen der Sonnenstrahlung, von Dr. J. M. Pernter (15 pp.). This is an abstract of Prof. Langley's paper on the Mount Whitney results, published as a *Professional Paper of the Signal Office* in 1884. Prof. Langley, finding all actinometers unsatisfactory, invented a special apparatus termed a "Bolometer," which is described in the *Proceedings of the American Academy*, Vol. XVI. Armed with this instrument he went to Mount Whitney, a station possessing the following qualifications:—1. a clear atmosphere; 2. a great altitude; 3. great steepness; 4. a low latitude; and 5. a dry climate. He had two stations, Lone Pine at the base and Mountain Camp at the summit, at the height of 11,625 feet, the difference of level between the stations was 7,864 ft. The cost of the expedition was mainly borne by a gentleman of Pittsburg who declines to allow his name to be published. As to the results, Prof. Langley says that if there were no atmosphere the sun would be blue. This conclusion he bases on the fact that the atmosphere exerts a selective absorption on the sun's rays, the most refrangible rays being the most absorbed. In this connection Langley states that no heat wave of such a length as could be emitted from the earth could ever pass through the atmosphere, accordingly all the dark heat rays emanating from the earth are absorbed by the atmosphere. The nearer the earth the air strata lie the less transparent are they for solar rays. Accordingly it cannot be assumed that the atmosphere acts as a homogeneous body for the absorption of the individual rays. Finally, it appears that actinometer observations throw no light on the subject of radiation, and that even with the bolometer results are far from conclusive, as we are ignorant of the law according to which the co-efficient of transmission increases with the height. Temperaturleitung und Strahlung der ruhenden Atmosphäre, von Dr. J. Maurer (6 pp.).—Fahrt des Militär-Ballons Barbara am 10 December 1885, von Major F. H. Buchholtz (2 pp. and plate).—Gewitterperioden in Wien, von Dr. J. Hann (12 pp.).—Einiges über Gewittererscheinungen im Riesengebirge, insbesondere auf der Schneekoppe, von Prof.

Dr. E. Reimann (8 pp.).—Von der Möglichkeit über die Temperatur-verhältnisse kommender Jahre und Jahreszeiten sich im Voraus eine Meinung zu bilden, von A. Magelssen (6 pp. and plate).

Revue maritime et coloniale. April 1886. 8vo.

Contains:—L'Ouragan de Juin 1885, dans le Golfe d'Aden, par le Vice-Amiral G. Cloué (63 pp. and chart). This is an account of the same cyclone as is described by Capt. M. T. Moss on page 174 of the present No. of the *Quarterly Journal*, and by M. Millot in the *Annuaire de la Société Météorologique.*

Royal Cornwall Polytechnic Society. The Fifty-Third Annual Report, 1885. 8vo. 1886.

This contains a full account (13 pp.) of the action taken by the Society for the erection of the new Falmouth Observatory. The foundation stone was laid by the Earl of Mount Edgcumbe, on August 12th, 1884; and the building was completed and the instruments put in position on May 9th, 1885.—Mr. W. L. Fox also contributes a set of "Tables of Sea Temperature, Bright Sunshine and Climate at Falmouth for the year 1885, and Notes, with other Meteorological Tables for West Cornwall and the Scilly Islands" (12 pp. and diagram).

Scottish Geographical Magazine, 1886. 8vo.

This contains a Paper by Mr. W. B. Tripp on South Africa: its Physical Configuration and Rainfall; with notes on its Geology, Diamond and Coal Fields, and Forests, and two maps, showing contours and mean annual rainfall (6 pp.).

Sitzungsberichte der Königl. Böhmischen Gesellschaft der Wissenschaften in Prag. 1886. 8vo.

Contains:—Ueber die jährliche Periode der Richtung des Windes, von Prof. Dr. F. Augustin (22 pp. and plate). The author has investigated the data from a very large number of stations, and finds that as regards the annual rotation of the wind in both hemispheres the north and east coasts exhibit a right-handed, and the south and west coasts exhibit a left-handed rotation. The influence of the apparent path of the sun is shown by the fact that when its declination is northerly the wind moves against watch-hands, and when it is southerly it moves with watch-hands.

Società Meteorologica Italiana. Bollettino Mensuale pubblicato per cura dell' Osservatorio Centrale del Real Collegio Carlo Alberto in Moncalieri. Serie II., Vol. VI. Nos. 1-3. Jan.-March 1886. 4to.

Among other information this contains the following papers:—La Meteorologia nelle isole Filippine, del Capt. L. Gatta (5 pp.).—Modificazioni fatte all' Anemografo Denza per avere la Direzione dei Venti obliqui, e per ottenere maggior sensibilità nel Mulinello di Robinson da Francesco Cravero (1 p. and plate).—Pioggia di sabbia del 15 Ottobre 1885, del P. F. Denza (8 pp.).

Symons's Monthly Meteorological Magazine. April-June 1886. Vol. XXI. Nos. 243-245. 8vo.

Contains among other information, articles on the following subjects:—The Cold and the Snow Storm (4 pp.).—Meteorological and Astronomical Recurring Periods, by G. D. Brumham (2 pp.).—Earth Temperature and Weather in South Australia, by C. L. Wragge (1 p.).—Swedish Weather Proverbs (3 pp.).—Periodical Recurrence of Warm Summers, by G. T. Gwilliam and G. D. Brumham (2 pp.).—Barometric Wells (1 p.).—The May Floods of 1886 (3 pp.).—Flood Levels (2 pp.).—Great Rainfall (2 pp.).

The Naturalist's Diary. A Day-Book of Meteorology, Phenology and Rural Biology. Arranged and edited by Charles Roberts, F.R.C.S. 8vo. 1886. xlvii. + 365 pp. and map.

This Diary is intended to be used as a work of reference on many questions relative to climate, natural history, and rural economy; and as a journal in which to record facts and observations of a similar kind. To meteorologists, medical men, and others interested in sanitary questions and health resorts, it will serve as a standard of the climate and vegetation of the British Isles with which to compare local variations. It contains a chart showing the blossoming of spring flowers in Europe, and an Introduction on Natural Periodic Phenomena, &c.

QUARTERLY JOURNAL

OF THE

ROYAL METEOROLOGICAL SOCIETY.

Vol. XII. OCTOBER 1886. No. 60.

The Severe Weather of the Winter of 1885-6. By Charles Harding, F.R.Met.Soc. (Plate IV.)

[Read May 19th, 1886.]

In attempting to write a history of the past winter, considerable difficulty is experienced in limiting the period to be dealt with; and in the hope of rendering this paper as complete as possible the whole six months, from October 1885 to March 1886, have been considered in a general way, whilst the three months from January to March 1886 have been treated more in detail, as embracing the period during which the weather was most severe and in which both frost and snow were exceptionally prevalent.

Abnormally cold weather was experienced in the latter part of the summer which immediately preceded the period here especially dealt with, and as early as in August some days were quite autumnal, whilst the weather for the month was conspicuous for the entire absence of high summer temperatures.

September was also cold, and at the commencement of the month the dry weather, which had been so marked a characteristic of the summer, gave way to a period of heavy rains, weather of a very unsettled character having set in. It was not, however, until after the sun had crossed the Line that cold weather of a really exceptional character was experienced. It is very unusual for the shade temperature to fall below the freezing-point in any part of the Kingdom so early as September, but during the week ending the 28th lower temperatures were common over the whole of the British Islands, and

in the South-west of England the thermometer in the shade fell to 25°. At Greenwich Observatory the shade temperature fell to 30°·6 on the 27th, whilst on the grass, open to the sky, the thermometer registered 22°: the observations for September at Greenwich from 1841 do not show any previous shade temperature so low. The mean temperature for the 27th was 40°·5, which is 14°·1 in defect of the average; this is a lower value than any recorded in the Greenwich observations since 1814. This cold spell was accompanied by slight snow showers in many parts of England, and snow fell in London on September 25th; the earliest date shown by previous records at which snow has fallen in London was October 7th, 1829.

October was cold and cheerless, and the sensation was that we had been suddenly plunged into mid-winter; the cold continued throughout the month, and was uniform over the whole country. In London there were but three days, the 16th, 26th, and 27th, on which the temperature was in excess of the average, and the thermometer did not reach a higher temperature than 60° throughout the month. The Greenwich observations from 1841 do not show a previous October in which 60° has not been exceeded. The weather throughout the month was dull, wet, and unsettled, and numerous barometric depressions traversed all parts of our Islands.

November was particularly gloomy and damp, and both ground and air were kept in a state of saturation. In other respects the month may be characterised as one of ordinary average conditions, the temperature over the whole country approximating fairly to that usually experienced at that season.

December was a constant alternation influenced by the combined effect of cyclonic and anticyclonic conditions, the weather at one time being open and mild, whilst at another it was cold and frosty. The combined effect of the warm and cold spells resulted in a mean temperature in fair agreement with average conditions. The severest spell of cold weather was experienced from the 6th to 11th, when the temperature fell to 14° both in the North-west and South-west of England. Good skating was enjoyed in London and the suburbs on the 11th, and the skating was of a first-class character in all parts of the fen country—Cambridgeshire, Lincolnshire, Huntingdonshire, and Norfolk. Snow showers were experienced over the greater part of the Kingdom, and in Scotland some rather heavy falls occurred.

January was cold over the whole of the United Kingdom, but the weat[illegible] was extremely unsettled, severe frost alternating with brief periods of tha[illegible] Heavy falls of snow were experienced generally over the whole country, a[illegible] on the 6th the fall was particularly heavy in the East and South-east England. In and around London it was about 8 ins. deep, and traffic for time was greatly impeded. On the 8th, a very severe snowstorm occurred Scotland and the more northern parts of England. In London and in ma[illegible] parts of the country there was good skating both at the commencement a[illegible] end of the month. The period of greatest cold was in some places from t[illegible] 7th to 8th, and in others from the 19th to 23rd.

February was cold and dreary from beginning to end. The barometer w[illegible] higher and more uniform than usual, and the conditions decidedly anticyclonic

The area of greatest cold was over the eastern parts of England. No extremely low temperatures were recorded, but the cold was persistent in character, the coldest period being the close of the month. There have been in London during the present century but six Februaries with as low a monthly mean temperature, these were in 1814, 1827, 1838, 1845, 1853, and 1855, but of recent years 1873 and 1875 were only slightly warmer. Some heavy snow falls occurred over nearly the whole Kingdom, and fairly good skating was possible, especially during the second week.

March was cold, but very opposite conditions of weather were experienced during the month. From the commencement until the 18th, intense cold prevailed accompanied with biting East winds, and throughout this period an anticyclone was situated over the British Islands. Frequent heavy falls of snow took place, and more skating was enjoyed than in any previous March since the formation of the London Skating Club in 1830. After the 18th the frost entirely broke up, and for the remainder of the month the weather was unusually mild for the season.

Table I. gives the difference of temperature in degrees from the average for 20 years for the whole six months (September 21st, 1885, to March 21st, 1886), and for each week for all the twelve districts into which the Meteoro-

TABLE I.

DIFFERENCE OF MEAN TEMPERATURE FOR EACH WEEK FROM THE AVERAGE OF 20 YEARS, 1861–1880.

... ending	Scotland, North.	Scotland, East.	England, N.E.	England, East.	Midland Counties.	England, South.	Scotland, West.	England, N.W.	England, S.W.	Ireland, North.	Ireland, South.	Channel Islands.
385.												
pt. 28	−4°	−3°	−4°	−6°	−6°	−6°	−4°	−6°	−6°	−4°	−6°	−4°
. 5	−3	−2	−2	−3	−3	−2	−2	−3	−3	−4	−3	−3
12	−5	−4	−5	−6	−6	−6	−5	−6	−5	−5	−5	−5
19	−2	−2	−1	−4	−3	−4	−2	−3	−5	−1	−4	−5
26	−5	−5	−3	−4	−4	−3	−6	−5	−4	−4	−5	−4
v. 2	−1	avge.	−1	−3	−3	−3	−1	−3	−3	−1	−1	−2
9	+3	+4	+2	−1	+1	−1	+4	+1	+1	+3	+4	avge.
16	−2	−4	−1	−1	−2	avge.	−1	−3	−1	−1	−1	−2
23	−1	−5	−1	−2	−3	−2	−2	−4	−1	−1	avge.	avge.
30	avge.	+2	+4	+6	+6	+7	+3	+3	+6	+3	+5	+6
c. 7	−4	−1	avge.	avge.	avge.	+2	−1	−1	avge.	−2	−1	+2
14	−3	−2	−4	−6	−5	−6	−2	−5	−6	−3	−5	−4
21	+5	+6	+3	+4	+3	+3	+6	+2	−2	+5	+6	avge.
28	+2	+4	+1	−1	−1	−2	+2	−1	−3	+1	−1	−1
386.												
1. 4	−1	+3	+3	+3	+4	+3	+3	+3	+2	+2	+2	+2
11	−6	−6	−6	−6	−6	−6	−5	−6	−5	−4	−4	−3
18	−5	−3	−1	−2	−1	−1	−2	−2	−2	−3	−2	−1
25	−3	−5	−6	−6	−7	−7	−7	−8	−9	−7	−9	−6
b. 1	−3	−2	−3	−2	−2	avge.	−3	−4	−4	−4	−4	−1
8	−3	−4	−5	−6	−5	−6	−4	−6	−5	−2	−2	−3
15	+1	+2	−1	−6	−3	−5	+1	−1	−4	+1	avge.	−2
22	−3	−5	−6	−8	−7	−7	−4	−6	−7	−3	−3	−4
r. 1	−6	−7	−7	−9	−9	−9	−7	−9	−8	−7	−6	−5
8	−7	−7	−8	−9	−10	−9	−8	−10	−9	−7	−8	−6
15	−3	−8	−7	−9	−10	−10	−7	−10	−10	−7	−7	−9
22	avge.	avge.	−1	+1	+1	−2	avge.	−1	−1	avge.	+1	avge.

logical Office divides the British Islands in the discussion of its returns. From this Table it will be seen that there is no district in which the mean temperature was above the average in more than six weeks out of the twenty-six weeks dealt with. In the Channel Islands the temperature was only above the average during three weeks; whilst in the South, South-west, and North-west of England, and in the North of Scotland, it was only above the average in four weeks. The Table also shows that these high temperatures were almost wholly in November and December. The greatest deficiency of temperature was in the weeks ending January 25th, March 1st, 8th, and 15th, during which periods the defect from the average amounted to as much as 9° and 10° in several districts. For the fortnight ending March 15th, the mean in the Midland Counties and in the North-west of England was below the freezing-point, and, considering the British Islands as a whole, the temperature was lower during this fortnight than during any similar period of the winter; in connection with this it must not be overlooked that the average temperature for March is several degrees warmer than for January.

Table II. gives the monthly means for each of the six months from October to March for all the stations used by the Meteorological Office in the compilation of its *Weekly Weather Report*, which stations number about 70 and are fairly representative for each of the several districts, comprising the whole area of the British Islands. From this it will be seen that the resulting monthly means were below the average at all stations over the whole Kingdom in October, January, February, and March. In the East, South, North-west, and South-west of England, and the Channel Islands, as well as over the greater part of the Midland Counties and the North of Ireland, the temperature was also below the average in December. In the North-west of England the temperature was below the average in each of the six months, with one solitary exception of an excess of 0°·1 at Stonyhurst in November, and at two stations out of three in the North of Scotland the mean was below the average in each of the six months.

The amount in defect of the average was generally larger in February than in any other month. The greatest deficiency was in the East and South of England, and in the Midland Counties; the amounts at the several stations varying from 5° to nearly 9°.

Considering the actual mean temperatures, the coldest months were January and February. In Scotland and Ireland January was the coldest, whilst, with a very few exceptions in the North, February was the coldest over the whole of England and in the Channel Islands.

The several monthly means of the maxima and minima, as would naturally be expected, range in fair agreement with the means obtained from these combined data.

The means in the several districts and for each of the six months show the coldest weather to have been experienced as follows:—

October was coldest in Scotland.

November was coldest in Scotland and the Midland Counties.

December was coldest in the East of England and the Midland Counties.

TABLE II.

MONTHLY MEAN TEMPERATURE, OCTOBER 1885 TO MARCH 1886, AND THE DIFFERENCE FROM THE AVERAGE, 1861–1880.

Stations.	Mean of Max. and Min.						Difference from Average 1861 to 1880.						Mean Min.					
	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.
SCOTLAND, N.	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°
Sumburgh Head	42·7	41·6	39·5	35·7	36·1	37·1	—4·1	—0·2	—0·7	—3·5	—3·1	—2·0	38·4	37·6	35·1	31·7	32·3	32·6
Stornoway............	42·7	42·4	40·0	36·3	36·9	38·8	—3·5	+1·2	+0·5	—2·3	—2·5	—1·5	37·5	38·1	35·3	31·9	31·3	33·5
Wick	42·1	41·1	38·6	34·5	35·4	38·8	—4·2	—0·1	—0·5	—3·7	—3·5	—0·5	36·4	36·4	33·7	30·3	30·7	33·8
SCOTLAND, E.																		
Nairn	41·7	39·9	39·6	34·0	35·2	38·2	—5·3	—0·5	+1·5	—3·1	—3·7	—1·8	35·4	33·9	34·4	29·3	29·0	31·7
Aberdeen	43·3	40·5	38·2	34·9	35·1	37·7	—3·4	avge.	+0·4	—2·4	—3·5	—1·5	37·1	34·8	32·6	30·4	30·2	32·4
Leith	44·9	41·8	40·1	35·4	35·5	38·8	—2·8	+1·2	+1·8	—1·9	—4·0	—2·5	39·3	36·0	35·3	30·9	30·4	32·9
ENGLAND, N.E.																		
Alnwick Castle	44·1	42·1	39·1	34·5	34·5	38·0	—3·4	+1·2	+0·9	—2·6	—4·5	—2·0	40·2	38·1	35·2	30·4	30·6	33·5
Durham	..	41·4	37·5	34·2	34·0	37·9	..	..	..	—2·7	—5·1	—2·0	..	36·4	31·9	29·4	28·8	32·0
Shields	45·3	42·6	38·9	35·7	35·4	38·8	—2·7	+1·0	—0·2	—3·1	—4·1	—1·7	40·7	37·9	33·5	31·2	31·0	33·9
Scarborough	46·0	44·0	38·9	35·9	35·5	39·8	—2·3	+2·4	+0·8	—2·5	—3·6	—0·4	41·8	41·0	34·6	32·3	32·3	35·4
York	45·3	42·3	37·6	34·9	34·7	39·8	—3·9	+0·7	—1·0	—2·7	—4·9	—1·1	39·5	37·5	31·5	29·8	30·5	33·4
Spurn Head	46·4	43·6	38·8	36·2	34·4	38·2	—2·7	+1·2	+0·4	—2·3	—5·0	—2·4	42·4	40·6	34·9	32·9	31·4	33·6
ENGLAND, E.																		
Hillington	45·0	41·6	37·1	35·0	33·3	40·3	—4·5	—0·3	—1·2	—1·6	—6·2	—0·2	38·7	36·9	32·1	30·4	28·7	35·0
Yarmouth	45·9	43·4	37·9	35·4	33·1	38·2	—4·8	+0·7	—1·3	—2·7	—7·5	—3·2	41·4	40·2	33·5	31·7	30·4	33·9
Geldeston	45·7	43·0	38·1	35·7	33·8	39·4	—5·3	+0·3	—1·3	—2·1	—6·9	—2·1	40·2	38·7	33·3	30·8	29·7	33·9
Cambridge............	45·4	41·6	37·4	34·9	32·8	40·1	—5·1	—0·1	—1·4	—2·2	—7·7	—1·6	38·4	35·8	31·5	29·6	27·0	32·7
Rothamsted	45·3	42·2	37·7	32·8	31·3	38·9	—4·5	+1·1	—0·4	—4·3	—8·6	—2·5	39·1	37·2	32·4	28·7	28·1	32·6
MIDLAND COUNTIES.																		
Bawtry	45·2	42·1	38·4	34·9	34·5	38·8	—4·4	—0·2	—0·9	—3·3	—5·8	—2·7	39·4	37·5	32·5	29·2	29·6	31·7
Loughborough	45·4	42·0	38·3	36·1	34·5	39·9	—3·8	+0·9	+0·1	—0·9	—5·5	—1·3	39·2	36·8	32·9	31·7	29·6	33·0
Leicester	45·6	42·5	38·4	35·7	34·5	40·6	—3·4	+1·7	+0·5	—1·1	—5·3	—0·4	39·6	37·8	33·7	31·7	30·2	34·2
Cheadle	43·1	40·6	37·1	33·6	33·3	37·4	—5·0	+0·1	—0·9	—3·0	—6·0	—2·8	37·8	36·3	32·1	29·5	29·3	32·0
Churchstoke	43·6	41·3	37·7	34·6	34·1	37·7	—5·4	+0·7	—0·9	—3·1	—6·5	—3·3	37·5	36·3	32·1	29·5	29·0	31·7
Hereford	45·2	42·5	38·1	36·0	35·0	39·5	—4·6	+0·9	—0·8	—2·0	—5·9	—2·5	37·9	37·3	31·9	30·3	29·3	32·7
Cirencester	44·6	41·5	36·9	34·5	33·1	38·4	—5·2	+0·5	—2·0	—3·4	—6·9	—3·4	38·6	37·5	31·6	29·0	28·9	32·2
Oxford	46·0	42·6	38·4	35·9	34·2	39·8	—4·3	+0·2	—1·3	—2·7	—6·9	—2·4	40·2	38·1	33·4	31·2	30·2	33·4

TABLE II.—(*Continued.*)

MONTHLY MEAN TEMPERATURE, OCTOBER 1885 TO MARCH 1886, AND THE DIFFERENCE FROM THE AVERAGE, 1861–1880.

Stations.	Mean of Max. and Min.						Difference from Average 1861 to 1880.						Mean Min.					
	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.
ENGLAND, S.	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°
London	46.9	44.0	39.1	36.6	34.5	40.6	—4.2	+1.5	—0.4	—1.2	—6.7	—2.3	40.9	38.8	33.5	31.4	30.5	34.3
Strathfield Turgiss	46.5	42.8	37.6	35.6	33.6	39.9	—4.2	+0.8	—1.5	—2.5	—7.3	—2.8	39.6	37.3	32.0	29.9	28.7	32.6
Dungeness	47.8	45.3	40.1	37.7	35.4	39.0	—3.9	+0.9	—1.6	—2.0	—6.6	—4.3	41.7	40.8	35.1	32.5	31.4	33.7
Hastings	47.6	44.7	40.1	37.2	34.8	39.2	—3.8	+0.5	—1.3	—2.2	—6.8	—3.7	42.5	41.0	36.3	32.5	31.6	34.6
Southampton	47.9	44.6	39.7	37.5	36.3	40.7	—3.5	+1.4	+0.1	—1.1	—5.2	—2.7	41.3	39.8	34.9	32.3	31.3	34.8
Hurst Castle	48.6	45.6	41.0	39.1	36.5	39.1	—3.3	+0.9	—0.8	—2.9	—5.9	—4.7	42.9	41.3	35.3	33.8	31.4	33.9
Stowell	..	..	..	36.6	34.0	39.3	..	..	..	—2.8	—7.1	—3.1	..	..	..	31.4	29.6	33.6
SCOTLAND, W.																		
Laudale	43.4	42.6	41.7	35.8	36.7	39.7	—5.0	+0.6	+1.5	—3.3	—3.1	—0.8	38.1	38.7	37.6	30.6	32.2	35.2
Glasgow	43.4	41.1	39.1	34.8	35.1	37.9	—3.9	+0.8	+0.1	—3.4	—4.3	—2.8	38.0	37.0	34.6	29.6	31.4	33.6
Ardrossan	44.8	42.2	41.1	36.4	36.8	38.2	—3.3	+0.3	+2.1	—2.8	—2.8	—2.6	39.8	38.4	37.4	32.5	32.7	33.7
Douglas	45.6	44.2	41.2	37.8	37.9	39.1	—4.2	+1.6	—0.1	—2.4	—3.3	—3.2	40.9	40.8	37.3	34.0	34.3	35.2
ENGLAND, N.W.																		
Newton Reigny	42.6	39.5	36.5	32.7	32.9	37.3	—4.7	—1.1	—1.2	—4.1	—5.5	—2.9	37.3	34.0	30.7	27.8	27.8	31.2
Barrow-in-Furness	46.0	42.4	39.9	36.6	35.6	38.1	—4.0	—1.1	—1.1	—3.2	—5.5	—4.5	41.5	38.6	36.1	33.2	32.1	33.7
Stonyhurst	44.2	41.7	38.4	35.2	34.8	38.1	—4.5	+0.1	—0.4	—2.9	—4.8	—3.1	39.2	37.4	32.8	30.3	30.6	33.3
Blackpool	45.3	41.9	39.1	35.7	35.0	38.1	—5.2	—2.0	—2.0	—4.4	—6.5	—4.7	40.5	37.5	34.4	31.4	31.0	32.9
Manchester	44.0	42.1	38.5	35.1	35.1	39.0	—5.4	—0.1	—0.9	—3.4	—5.2	—2.5	39.1	37.8	33.6	31.3	31.5	33.8
Liverpool Obsy.	45.7	43.1	40.4	37.2	36.0	39.2	—4.8	—0.4	—0.3	—2.2	—5.4	—3.1	41.6	39.2	36.6	33.6	32.1	34.3
Llandudno	47.0	44.0	41.6	38.2	37.8	39.9	—4.5	—1.0	—0.6	—2.9	—4.5	—3.4	43.1	39.8	37.0	34.1	33.4	34.6
Holyhead	47.7	44.5	40.9	39.1	38.1	39.8	—4.0	—1.5	—2.9	—3.1	—4.9	—3.9	44.3	40.7	35.7	35.7	34.5	35.5
ENGLAND, S.W.																		
Llandovery	44.6	42.7	37.4	34.2	35.2	38.8	—6.3	—0.2	—3.1	—5.3	—6.7	—4.1	36.4	37.2	30.8	27.5	28.8	31.7
Pembroke	48.9	46.3	43.5	40.0	38.8	39.4	—3.8	+1.1	+0.4	—2.3	—4.9	—5.4	45.3	43.6	40.6	36.5	35.6	35.8
Arlington	46.0	44.4	38.8	36.2	35.0	39.0	—4.8	+1.6	—1.7	—3.8	—6.5	—3.4	41.0	40.3	33.8	31.4	29.8	33.6
Cullompton	47.1	45.2	38.7	36.8	35.2	40.7	—4.1	+1.4	—2.3	—3.9	—7.0	—2.4	40.6	40.5	32.8	30.8	29.6	34.8
Falmouth	49.0	48.8	43.4	40.2	40.1	42.1	—4.0	+2.6	—0.9	—2.9	—3.9	—2.9	44.6	45.9	39.7	35.9	36.8	38.5
Plymouth	48.2	47.4	41.6	38.5	37.9	41.5	—4.5	+1.8	—1.3	—3.8	—5.7	—3.3	42.0	43.1	36.2	32.6	32.6	36.5
Prawle Point	48.2	46.9	41.7	38.9	37.9	40.0	—4.1	+1.2	—1.2	—2.8	—5.4	—4.0	42.3	43.0	37.0	33.3	33.5	36.0

TABLE II.—(*Continued.*)

MONTHLY MEAN TEMPERATURE, OCTOBER 1885 TO MARCH 1886, AND THE DIFFERENCE FROM THE AVERAGE, 1861–1880.

Stations.	Mean of Max. and Min.						Difference from Average 1861 to 1880.						Mean Min.					
	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.
IRELAND, N.																		
	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°
Malin Head	46·2	44·5	43·3	38·9	39·4	39·8	−2·2	+1·6	+1·6	−1·1	−1·1	−1·8	42·2	41·0	39·7	34·6	35·4	34·9
Londonderry	45·1	43·6	41·8	37·4	38·9	41·3	−3·3	+1·0	+1·3	−3·2	−1·6	−0·3	39·4	38·0	36·7	31·8	33·3	35·4
Mullaghmore	47·2	45·6	43·4	39·2	40·0	41·5	−1·4	+2·4	+1·7	−3·1	−1·2	−1·2	43·5	42·3	40·0	35·9	35·6	37·0
Belmullet	47·0	45·1	43·4	39·7	40·5	40·8	−3·6	−0·5	−0·4	−4·8	−3·1	−4·3	43·3	42·1	40·1	35·8	36·2	36·6
Markree Castle	44·4	42·7	39·6	36·4	37·1	39·1	−4·0	+0·3	−1·3	−5·4	−3·3	−3·2	38·4	37·5	34·1	30·9	30·9	32·4
Brookeborough	43·8	42·8	39·1	35·0	37·5	39·5	−3·9	+1·3	−0·7	−5·0	−2·3	−1·2	37·8	37·9	33·9	29·5	31·9	33·8
Armagh..............	44·3	42·9	39·9	35·5	37·9	39·8	−3·8	+0·7	−0·2	−4·0	−3·1	−2·3	38·3	37·8	35·3	30·5	33·2	34·3
Donaghadee	45·8	44·5	40·9	37·5	37·9	39·4	−4·4	+1·4	−0·4	−2·8	−3·3	−3·8	41·4	40·8	36·8	33·6	33·8	35·1
Edgeworthstown	44·2	43·4	39·0	35·5	37·1	39·2	−3·7	+1·7	−0·7	−3·5	−2·9	−1·7	38·3	38·9	34·5	31·1	31·8	32·8
IRELAND, S.																		
Dublin	45·5	45·9	42·0	37·9	39·7	41·4	−4·3	+2·2	+0·7	−2·5	−2·5	−1·8	40·6	41·8	37·8	33·6	35·4	36·5
Parsonstown	44·2	44·3	40·2	35·5	38·3	40·2	−4·7	+2·0	+0·2	−4·3	−2·6	−1·4	37·8	39·0	34·8	30·1	32·5	33·1
Kilkenny	44·9	45·3	39·8	36·0	38·9	40·2	−4·2	+2·2	−0·2	−3·2	−2·4	−1·3	38·7	40·4	34·6	30·9	33·9	34·0
Waterford............	46·0	45·6	40·4	37·0	39·8	40·0	−5·2	+1·0	−1·9	−4·1	−3·8	−4·3	39·6	41·5	35·8	32·1	35·8	35·3
Roche's Point	47·9	47·6	43·9	40·3	42·5	42·2	−3·8	+0·4	+0·8	−2·3	−1·8	−2·4	42·5	43·4	39·4	35·4	38·0	37·8
Valencia	49·3	48·5	44·8	41·8	43·6	43·8	−3·1	+2·1	−0·7	−3·2	−1·8	−1·9	44·3	44·2	40·2	37·2	39·1	39·2
Killarney	46·2	46·6	42·0	38·5	41·2	41·7	−5·1	+0·4	−1·4	−4·8	−2·5	−2·9	40·4	41·9	36·4	32·7	35·9	36·0
CHANNEL ISLANDS.																		
Scilly	50·9	50·3	46·2	43·4	43·0	43·6	−3·9	+1·3	−0·9	−2·4	−3·0	−3·0	47·6	47·5	43·0	39·9	39·8	40·1
Jersey	50·5	46·9	43·0	41·0	38·8	41·9	−4·2	+0·6	−0·5	−0·9	−3·7	−1·9	46·8	43·9	39·6	37·3	36·1	37·6

January was cold over the whole Kingdom, but the frost was most intense in the Eastern and Midland districts.

February was coldest over the East of England and the Midland Counties.

March was cold over the whole Kingdom, but rather less so in the West than in other parts.

Table III. gives the absolute minima in the several districts for each week during the six months in question, the arrangement being similar to that followed in Table I. It shows that the absolutely lowest temperature for these representative stations during the whole winter was 6°, which occurred in the East of England during the week ending January 11th. The next lowest temperature was 7° in the North-west of England during the week ending January 25th, and in the same week 8° was registered in the North of Scotland. The lowest temperature for the winter in all districts occurred in one of these two weeks ending January 11th or 25th. The minima for the two weeks ending March 8th and 15th were, however, but very slightly higher, the lowest readings were 10° in the North-west of England and 11° in the Midland Counties.

TABLE III.

MINIMUM TEMPERATURE IN EACH WEEK.

Week ending		Scotland, North.	Scotland, East.	England, N.E.	England, E.	Midland Counties.	England, South.	Scotland, West.	England, N.W.	England, S.W.	Ireland, North.	Ireland, South.	Channel Islands.	In whole of British Islands.
1885.		°	°	°	°	°	°	°	°	°	°	°	°	°
September	28	29	32	30	31	28	30	31	30	25	29	30	44	25
October	5	35	34	39	36	34	37	39	39	34	35	35	47	34
	12	30	26	31	33	28	30	29	26	30	33	36	43	26
	19	35	36	37	35	28	31	33	34	29	32	34	42	28
	26	22	20	35	34	28	33	26	29	25	27	28	41	20
November	2	30	31	31	30	29	31	33	26	30	32	33	43	26
	9	32	27	31	29	30	30	34	31	31	33	35	40	27
	16	27	20	30	26	24	26	23	20	25	20	22	37	20
	23	25	18	22	24	22	28	19	23	29	26	27	31	18
	30	34	31	32	33	35	36	36	30	32	31	33	45	30
December	7	21	23	20	29	23	30	20	18	24	19	30	42	18
	14	20	19	16	16	17	19	22	14	14	18	19	32	14
	21	32	32	31	30	30	29	37	27	30	36	34	36	27
	28	30	30	28	26	25	23	28	21	23	23	23	31	21
1886.														
January	4	22	25	22	23	22	26	25	24	31	25	29	34	22
	11	20	15	18	6	10	11	19	15	13	15	16	32	6
	18	18	19	18	27	21	27	17	15	22	24	24	35	15
	25	8	12	13	14	14	23	20	7	14	14	18	27	7
February	1	22	27	28	24	29	28	28	28	21	27	24	34	21
	8	22	18	24	21	21	23	15	15	20	22	22	30	15
	15	29	28	26	14	21	18	28	27	23	26	25	28	14
	22	26	23	20	28	23	26	27	25	24	25	24	34	[illegible]
March	1	16	21	22	21	22	22	21	19	24	21	26	30	[illegible]
	8	24	22	15	18	11	18	21	10	15	20	16	31	[illegible]
	15	22	16	13	21	15	24	20	15	16	16	20	29	[illegible]
	22	30	24	27	19	20	18	30	27	17	26	22	32	[illegible]
Lowest in 6 months.		8	12	13	6	10	11	15	7	13	14	16	27	6

This Table also shows that, omitting the Channel Islands, there was no district in the British Islands in which the temperature for each week did not fall to the freezing-point, or below it, from the commencement of January until the third week in March. In the South-west of England there was only a single exception of a week in which the thermometer did not fall to the freezing-point from September 21st to March 21st, and not a single exception after the first week in October. In each of the districts Scotland E., England N.E., and England N.W., the temperature fell to 32° or below in each week from the commencement of November until the third week in March, and in England E. and S., and in the Midland Counties, there was no exception from the commencement of December.

Table IV. gives the lowest shade temperatures recorded in January, February, and March at all the stations. It shows that the lowest temperature, 6°, occurred at Rothamsted in Hertfordshire on the night of January 7th-8th. The Table also shows that the January minima at many stations occurred at this time, but this was by no means uniformly the case. In the North-west and South-west of England the minima for the month occurred generally between the 19th and 21st. The minima in February were not so low, nor were they at all uniform in their period of occurrence. In March the lowest temperature was 10° at Newton Reigny, near Penrith, on the 7th, and the minima over nearly the whole of Great Britain occurred on this day.

The Table, as well as Plate IV., shows the number of times that the thermometer fell to 32° or below in each of the three months from January to March, the total number of nights in many parts of the British Islands exceeding 60, the absolutely highest number was 66 nights at Llandovery; and in addition, the Table IV. shows the number of days with the thermometer below 20°. The latter are by no means common, and clearly indicate that the frost was not in any way remarkable for its low readings; but both the Table and the Plate, on the other hand, show, by the number of times the thermometer fell to the freezing-point, and also the long period that the minimum temperature was continuously at this point or below, that the frost was one of very exceptional length.

The longest uninterrupted continuance of the frost was generally experienced in the Midland Counties and in the East of England. At Cheadle in Staffordshire, Churchstoke in Montgomery, Llandovery in Carmarthen, and Great Berkhamsted in Hertfordshire, frost occurred on 33 consecutive nights, from February 14th to March 18th, whilst at several stations the frost continued 30 days or more.

In Great Britain, the longest period of frost during the winter occurred between the middle of February and the middle of March, and Plate IV. exhibits very clearly how few days there were during this period on which frost did not occur. In Ireland, however, the longest period of frost occurred generally in January.

Table IV. also gives the number of days on which snow fell for stations considered representative of the British Islands.

Table V. gives the number of days that the minimum temperature at

TABLE IV.

Lowest Temperatures in January, February, and March 1886.

Stations.	January.				February.				March.				Longest continuous period with min. temp. 32° or below.		Days with Snow.		
	Absolute.	Date.	No. of times		Absolute.	Date.	No. of times		Absolute.	Date.	No. of times		Date.	Days.	Jan.	Feb.	Mar.
			32° or below.	Below 20°.			32° or below.	Below 20°.			32° or below.	Below 20°.					
Scotland, N.	°				°				°								
Sumburgh Head	25	5, 12	18	..	25	26	15	..	24	7	16	..	Feb. 24—Mar. 12	17	12	9	7
Stornoway	20	18	16	..	22	3	15	..	22	12, 13	13	..	{ Jan. 30—Feb. 5 / Feb. 25—Mar. 3 }	7	11	6	7
Wick	8	19	21	2	16	25	17	2	25	7	15	..	Jan. 5–22	18	12	7	8
Scotland, E.																	
Nairn	12	19	23	2	18	5, 6	21	2	16	12	18	1	Feb. 23—Mar. 18	24	15	6	3
Aberdeen	15	7	17	3	23	6	20	..	19	12	18	1	Feb. 24—Mar. 18	23	9	15	13
Leith	12	19	17	2	19	5	20	2	22	7	18	..	Feb. 24—Mar. 18	23	12	10	10
England, N.E.																	
Alnwick Castle	17	19	18	2	20	19	19	..	20	9	14	..	Mar. 5–16	12	..	..	..
Durham	13	20	21	3	20	20	22	..	13	10	18	3	Feb. 18—Mar. 18	29	..	..	..
Shield	19	8	17	1	25	26	19	..	19	7	17	1	Mar. 6–18	13	9	10	8
Scarborough	22	19	14	..	28	24	13	..	25	7	13	..	Feb. 23—Mar. 3	9	..	..	..
York	16	19, 20	18	4	25	27	20	..	16	7	17	2	Feb. 19—Mar. 17	27	9	5	5
Spurn Head	26	8	14	..	27	9, 10	20	..	24	10	16	..	Feb. 20—Mar. 16	25	14	7	10
England, E.																	
Hillington	21	19	21	..	22	7	24	..	22	7	17	..	Feb. 17—Mar. 17	29	..	..	..
Yarmouth	23	8	22	..	24	10	25	..	25	7	18	..	Feb. 16—Mar. 18	31	9	9	9
Geldeston	21	8	17	..	20	10	22	..	22	7	17	..	Feb. 16—Mar. 17	30	..	..	..
Cambridge	22	8	20	..	19	10	23	1	19	7	18	1	Feb. 15—Mar. 18	32	10	4	5
Rothamsted	6	8	21	2	14	9	25	2	18	7	18	2	Feb. 15—Mar. 18	32	..	..	..
Mid. Counties.																	
Bawtry	14	19	23	2	23	15, 27	23	..	11	8	18	5	Feb. 15—Mar. 18	32	..	..	..
Loughborough	24	19, 20	17	..	22	15	20	..	16	7	18	2	Feb. 19—Mar. 18	28	13	10	10
Leicester	24	7	19	..	24	24	20	..	18	7	17	1	Feb. 18—Mar. 17	28	..	..	..
Cheadle	22	24	24	..	24	7, 24	24	..	18	7	18	1	Feb. 14—Mar. 18	33	..	..	..
Churchstoke	15	7	17	1	21	5, 15	22	..	13	7	18	2	Feb. 14—Mar. 18	33	..	..	..
Hereford	13	8	19	2	22	15	22	..	15	7	18	2	Feb. 19—Mar. 18	28	..	..	..
Cirencester	10	8	25	[illegible]	21	10	23	..	15	7	18	1	Feb. 15—Mar. 18	32	..	..	..
Oxford	14	8	16	2	23	10	21	..	[illegible]	17	18	..	Feb. 23—Mar. 18	24	11	4	8

LOWEST TEMPERATURES IN JANUARY, FEBRUARY, AND MARCH 1886.

Stations.	January.				February.				March.				Longest continuous period with min. temp. 32° or below.		Days with Snow.		
	Absolute.	Date.	No. of times 32° or below.	No. of times Below 20°.	Absolute.	Date.	No. of times 32° or below.	No. of times Below 20°.	Absolute.	Date.	No. of times 32° or below.	No. of times Below 20°.	Date.	Days.	Jan.	Feb.	Mar.
England, S.																	
London	18°	8	19	1	22°	9, 10	16	..	21°	7, 17	18	..	Feb. 20—Mar. 18	27	14	4	7
Strathfield Turgiss	11	8	21	2	18	10	20	1	18	7, 17	18	2	Feb. 17—Mar. 18	30	..	..	..
Dungeness	14	8	14	1	24	10, 27, 28	15	..	22	7, 17	19	..	Feb. 22—Mar. 19	26	5	2	3
Hastings	26	9, 20, 23	16	..	25	9	15	..	25	4, 7	17	..	Feb. 21—Mar. 17	25	..	..	..
Southampton	25	7, 8, 19, 21	16	..	23	10	16	..	22	7, 17	17	..	Feb. 21—Mar. 17	25	..	..	..
Hurst Castle	26	8	15	..	23	10	15	..	22	7	17	..	Mar. 3-18	16	6	0	4
Stowell	22	8	17	..	22	10	20	..	19	7, 17	17	2	Mar. 3-18	16	..	..	..
Scotland, W.																	
Laudale	17	18	17	2	20	4	11	..	20	12	13	..	Jan. 17-25	9	..	..	..
Glasgow	19	7, 18	23	3	15	5	16	2	21	7	15	..	Jan. 16-27 / Mar. 5-16	12	..	..	..
Ardrossan	22	7	15	..	25	4	16	..	24	7	17	..	Feb. 24—Mar. 17	22	10	5	4
Douglas	21	7	11	..	25	5	8	..	26	7	12	..	Feb. 28—Mar. 7	8	..	..	..
England, N.W.																	
Newton Reigny	7	20	20	5	15	4, 5	18	3	10	7	17	3	Feb. 23—Mar. 16	22	..	..	..
Barrow-in-Furness	25	20	13	..	27	5, 6, 26	12	..	24	7	18	..	Feb. 24—Mar. 18	23	4	3	3
Stonyhurst	16	19	17	3	24	5, 24, 26	16	..	14	7	18	1	Feb. 23—Mar. 18	24	..	..	..
Blackpool	15	20	16	1	23	5, 26	12	..	19	7	18	1	Feb. 24—Mar. 18	23	..	..	..
Manchester	20	19, 20	17	..	25	24, 26	14	..	17	7	18	1	Feb. 23—Mar. 18	24	..	..	..
Liverpool Obsy.	25	20	12	..	27	24	17	..	21	7	18	..	Feb. 24—Mar. 18	23	10	2	7
Llandudno	25	24, 25	11	..	25	26	12	..	23	7, 14	17	..	Feb. 23—Mar. 17	23	..	..	..
Holyhead	22	25	18	..	25	5	8	..	28	5, 10, 11, 12	16	..	Mar. 1-16	16	5	1	2
England, S.W.																	
Llandovery	13	6, 7	25	2	20	4	24	..	15	3	17	4	Feb. 13—Mar. 17	33	..	..	..
Pembroke	27	21, 23	9	..	31	26	7	..	28	11, 12, 13, 18	14	..	Mar. 10-18	9	6	4	2
Arlington	21	27	19	..	24	5, 10	20	..	20	4	18	..	Feb. 24—Mar. 18	23	..	..	..
Cullompton	14	21	20	1	23	10	21	..	19	4, 7	15	2	Jan. 18-30	13	..	..	..
Falmouth	26	21	8	..	31	26	1	..	28	13, 14	6	..	Mar. 11-14	4	..	..	..
Plymouth	23	21	15	..	25	5	14	..	24	4, 7	12	..	Jan. 19-29	11	..	..	..
Prawle Point	25	8, 21, 23	16	..	29	5, 6, 10	9	..	27	7	16	..	Mar. 3-18	16	8	0	2

TABLE IV.—(*Continued.*)

LOWEST TEMPERATURES IN JANUARY, FEBRUARY, AND MARCH 1886.

Stations.	January.				February.				March.				Longest continous period with min. temp. 32° or below.		Days with Snow.		
	Absolute.	Date.	No. of times 32° or below.	No. of times Below 20°.	Absolute.	Date.	No. of times 32° or below.	No. of times Below 20°.	Absolute.	Date.	No. of times 32° or below.	No. of times Below 20°.	Date.	Days.	Jan.	Feb.	Mar.
IRELAND, N.	°				°				°								
Malin Head	26	8	11	..	30	25, 27	8	..	26	10, 17	16	..	Feb. 24—Mar. 4 / Mar. 10–18	9	8	4	5
Londonderry	22	23	14	..	26	4	15	..	23	13	18	..	Feb. 28—Mar. 7	8	..	..	..
Mullaghmore	28	23	8	..	28	4	7	..	30	11, 14, 15	10	..	Mar. 1–5 / Mar. 11–15	5	11	0	8
Belmullet	28	7, 18, 21	7	..	30	25, 26	3	..	28	13	12	..	Mar. 1–6	6	3	1	5
Markree Castle	17	7	16	1	21	25	16	..	16	13	18	2	Mar. 10–18	9	..	..	..
Brookeborough	14	21	20	2	23	4	17	..	21	4, 13	17	..	Jan. 15–25	11	..	..	..
Armagh	20	7, 20, 21, 23	20	..	26	4	14	..	22	12	16	..	Jan. 15–25	11	..	..	..
Donaghadee	22	7	12	..	27	5	12	..	27	13	11	..	Jan. 30—Feb. 5 / Mar. 1–7	7	9	3	4
Edgeworthstown ..	17	7	21	1	24	5, 25	19	..	21	4, 14	16	..	Feb. 23—Mar. 7	13	..	..	..
IRELAND, S.																	
Dublin	25	7	8	..	27	5	4	..	23	4	12	..	Mar. 1–7	7	..	..	..
Parsonstown	18	7, 24	19	4	24	5	12	..	19	4, 5	15	1	Jan. 16–30	15	11	1	3
Kilkenny	16	7	18	2	24	5	12	..	16	4	14	1	Jan. 16–30	15	..	..	..
Waterford..........	22	7	16	..	22	5	5	..	23	13	13	..	Jan. 16–28	13	..	..	..
Roche's Point	28	7	11	..	31	5	2	..	28	4, 13	8	..	Jan. 21–27	7	3	0	4
Valencia	27	7, 26	7	..	31	26	1	..	27	13	5	..	Jan. 24–27	4	1	0	0
Killarney	20	7, 21	11	..	25	15	7	..	20	4	12	..	Feb. 28—Mar. 6	7	..	..	..
CHANNEL ISLANDS.																	
Scilly	34	23, 24	..	..	36	10, 26, 27	..	..	33	13, 14	..	..	..	0	0	0	0
Jersey	27	21	2	..	28	9	5	..	29	10, 11	8	..	Mar. 9–15	7	6	0	1

TABLE V.

OF TIMES THE MINIMUM TEMPERATURE WAS 32° OR BELOW AT THE ROYAL OBSERVATORY, GREENWICH, 1845–1886.

Year.	Jan.		Feb.		Mar.		Longest continuous period, 32° or below, in Three Months, Jan. to March.		Longest continuous period, 32° or below, in Whole Winter.		
	32° or below.	Below 20°.	32° or below.	Below 20°.	32° or below.	Below 20°.	Date.	Days.	Year.	Date.	Days.
	Dys.	Dys.	Dys.	Dys.	Dys.	Dys.					
1845	12	...	19	2	18	2	Mar. 12-21	10	1844-5	Dec. 5-15	11
1846	4	...	6	...	6	...	Feb. 8-12 Mar. 17-21	5	1845-6	Feb. 8-12 Mar. 17-21	5
1847	18	...	18	5	13	1	Jan. 10-21	12	1846-7	Dec. 24—Jan. 4 Jan. 10-21	12
1848	23	1	7	...	5	...	Jan. 20-29	10	1847-8	Jan. 20-29	10
1849	13	1	7	...	6	...	Jan. 1-7	7	1848-9	Jan. 1-7	7
1850	24	...	3	...	13	...	Jan. 5-18	14	1849-50	Jan. 5-18	14
1851	3	...	9	...	2	...	Feb. 15-17 Feb. 27—Mar. 1	3	1850-1	Dec. 20-24	5
1852	5	...	7	...	15	...	Mar. 1-8	8	1851-2	Mar. 1-8	8
1853	3	...	21	...	18	...	Feb. 11-24	14	1852-3	Feb. 11-24	14
1854	8	2	10	...	10	...	Mar. 1-7	7	1853-4	Dec. 24—Jan. 6	14
1855	20	2	22	10	16	...	Jan. 14—Feb. 3	21	1854-5	Jan. 14—Feb. 3	21
1856	10	...	6	...	13	...	Jan. 28—Feb. 4	8	1855-6	Jan. 28—Feb. 4	8
1857	19	...	12	...	9	...	Jan. 26—Feb. 5	11	1856-7	Jan. 26—Feb. 5	11
1858	17	...	22	...	14	...	Feb. 17—Mar. 12	24	1857-8	Feb. 17—Mar. 12	24
1859	6	...	6	...	2	...	Feb. 3-5	3	1858-9	Nov. 18-24	7
1860	8	...	18	...	9	...	Feb. 9-15	7	1859-60	Dec. 10-20	11
1861	22	5	5	...	2	...	Jan. 1-19	19	1860-1	Jan. 1-19	19
1862	11	...	5	...	4	...	Jan. 16-22	7	1861-2	Jan. 16-22	7
1863	4	...	8	...	8	...	Feb. 13-18	6	1862-3	Feb. 13-18	6
1864	13	2	17	...	10	...	Jan. 1-9	9	1863-4	Dec. 31—Jan. 9	10
1865	17	3	14	1	17	...	Mar. 18-31	14	1864-5	Mar. 18-31	14
1866	6	...	10	...	11	...	Feb. 27—Mar. 5	7	1865-6	Feb. 27—Mar. 5	7
1867	18	7	...	...	17	...	Jan. 11-22	12	1866-7	Jan. 11-22	12
1868	17	...	5	...	5	...	Jan. 1-11	11	1867-8	Dec. 25—Jan. 11	18
1869	8	...	2	...	16	...	Jan. 19-25	7	1868-9	Jan. 19-25	7
1870	12	1	15	1	13	...	Feb. 9-19	11	1869-70	Feb. 9-19	11
1871	20	2	5	...	7	...	Jan. 1-6	6	1870-1	Dec. 21—Jan. 6	17
1872	2	...	...	...	10	...	Mar. 20-27	8	1871-2	Dec. 2-11	10
1873	8	...	18	...	6	...	Feb. 18-25	8	1872-3	Feb. 18-25	8
1874	6	...	15	...	9	...	Feb. 4-12	9	1873-4	Feb. 4-12	9
1875	3	1	21	...	14	...	Feb. 4-11 Feb. 18-25	8	1874-5	Dec. 14-23	10
1876	19	2	9	...	10	...	Jan. 5-16	12	1875-6	Nov. 29—Dec. 10 Jan. 5-16	12
1877	7	...	3	...	12	...	Mar. 8-12	5	1876-7	Mar. 8-12	5
1878	11	...	5	...	11	...	Jan. 29—Feb. 1 Feb. 6-9 Mar. 14-17 Mar. 23-26	4	1877-8	Dec. 25-28 Jan. 29—Feb 1. Feb. 6-9 Mar. 14-17 Mar. 23-26	4
1879	26	1	12	...	11	...	Jan. 2-12 Jan. 16-26	11	1878-9	Dec. 6-26	21
1880	23	5	6	...	4	...	Jan. 24—Feb. 2	10	1879-80	Nov. 20—Dec. 11	22
1881	19	10	11	...	11	...	Jan. 11-26	16	1880-1	Jan. 11-26	16
1882	8	...	6	...	4	...	Jan. 21-26	6	1881-2	Jan. 21-26	6
1883	4	...	3	...	22	...	Mar. 3-13	11	1882-3	Mar. 3-13	11
1884	2	...	5	...	4	...	Feb. 29—Mar. 3	4	1883-4	Nov. 12-15 Feb. 29—Mar. 3	4
1885	20	...	4	...	13	...	Jan. 1-10	10	1884-5	Dec. 31—Jan. 10	11
1886	18	1	17	...	18	...	Feb. 19—Mar. 18	28	1885-6	Feb. 19—Mar. 18	28

Greenwich Observatory was 32° or below, also the number of days below 20° for each year from 1845 to 1886, for January, February, and March. It also gives the longest period during these three months that the minimum temperature was continuously at 32° or below, as well as the longest period in each winter that the minimum temperature was continuously at 32° or below. It shows that in 1886 the minimum fell to 32° or below for twenty-eight consecutive days, from February 19th to March 18th, and the Table does not contain any other instance of frost continuing for so long a period without interruption. The only instances of frost for twenty or more consecutive days at Greenwich from 1845 are:—

24 days in 1858, from February 17th to March 12th.
22 days in 1879, from November 20th to December 11th.
21 days in 1855, from January 14th to February 3rd.
21 days in 1878, from December 6th to December 26th.

Considering the three months from January to March, there are but few years since 1845 that have a period of continuous frost of one half the length of that in 1886. The years with fifteen days or more are respectively:—

1886, 28 days.
1858, 24 days.
1855, 21 days.
1861, 19 days.
1881, 16 days.

Taking the actual days with frost, irrespective of continuity, there were in London frost on fifty-three days in the present year (1886), from January to March. In 1855 the number of frosts in the corresponding period was fifty-eight, but the only other instance of more than fifty days was in 1858, when the number was fifty-three.

There was only one night from January to March 1886 on which the thermometer fell below 20°, but each of the following years had five or more such frosts in the period:—

1855, 12 nights.	1847, 6 nights.
1881, 10 ,,	1861, 5 ,,
1867, 7 ,,	1880, 5 ,,

Mr. W. Lucas, writing on March 4th from Hitchin, remarks that winter began with him in August, and gives the following results of thirty-seven years' observations:—

No colder August.
3 colder Septembers.
1 colder October.
11 colder Novembers.
7 colder Decembers.
6 colder Januaries.
1 colder February.

The average temperature of the seven months was 10° below the mean, and he states that "the ice on which we skated early in December, and even

November, has never thawed, and has borne all the time, and the snow ifts which fell in December in many places are almost undiminished."

The following are a few of the most extreme minimum temperatures elow 10°) from stations other than those used in the Tables:—

JANUARY.

Station.	Shade temp.	On grass.	Date.
	°	°	
Braemar	−2·0	—	19
Alston	1·1	—	20
Stapleton	4·8	—	20
Buxton	6·6	—	20
Berkhamsted[1]	7·4	0·9	8
Do.	9·2	−4·6	7
Ross	8·6	—	7
Pawston, Cornhill on Tweed ...	9·0	—	19 and 20
Skipton	9·0	—	20
Beddington	9·2	—	8
FEBRUARY.			
Braemar	2·5	—	5
Alston	7·1	—	5
MARCH.			
Alston	−2·0	—	7
Buxton	1·2	—	7
Braemar	2·0	—	12
Tean Vicarage	7·0	—	7
Jedburgh	8·0	—	7
Hodsock	8·4	—	7
Bishop's Castle, Salop ...	9·0	—	7

Probably the most interesting feature in connection with the past winter as the excessively cold weather experienced over the whole country at the ommencement of March. The following are the mean temperatures from the st to 17th at a few stations, which may be considered representative of the ritish Islands, and which are arranged approximately in order of latitude:—

TABLE VI.

MEAN TEMPERATURES, MARCH 1ST TO 17TH, 1886.

Station.	Mean Max.	Mean Min.	Mean Temp.
	°	°	°
Nairn	37·8	25·6	31·7
Aberdeen	37·1	27·9	32·5
Glasgow	36·5	27·7	32·1
Shields	36·5	28·8	32·7
Newton Reigny	36·2	23·6	29·9
Rounton	36·2	25·4	30·8

[1] The observations at Berkhamsted were made by Mr. E. Mawley, F.R.Met.Soc.; the ass thermometer was placed on the surface of the snow.

TABLE VI.—(*Continued.*)

MEAN TEMPERATURES, MARCH 1ST TO 17TH, 1886.

Station.	Mean Max.	Mean Min.	Mean Temp.
	°	°	°
Brookeborough (Fermanagh)	40·2	27·6	33·9
York	38·0	27·1	32·6
Hodsock	36·6	22·5	29·6
Liverpool	36·4	27·6	32·0
Parsonstown (King's County)	40·9	26·0	33·5
Lowestoft	37·3	29·9	33·6
Aspley Guise	36·7	25·1	30·9
Colwall, Malvern	35·8	24·9	30·3
Cardiff	39·2	28·8	34·0
Margate	37·5	29·8	33·7
Greenwich	39·0	26·6	32·8
Norwood	37·9	26·9	32·4
Tenterden	37·0	26·0	31·8
Harestock	38·7	25·3	32·0
Stowell	38·6	25·9	32·3
Cullompton	40·3	27·1	33·7
Babbacombe	39·5	31·0	35·3

It will be seen that the mean for the period ranged within a degree or two of the freezing-point, above or below, over the whole country.

The Greenwich observations from 1814 only show two instances of a similarly low temperature in March. In 1814, the mean for the 1st to 17th was 31°·4, and there were fourteen days between the 1st and 19th with the mean temperature at or below the freezing-point. The whole winter of 1814 was exceptionally severe, the frost being very prolonged. In 1845, the mean for the 1st to 17th was 29°·8, and there were eleven days between the 1st and 18th with the mean temperature at or below the freezing-point—this frost was also very prolonged.

Mr. Mawley has supplied the following facts relative to the weather experienced at Great Berkhampsted. They are of especial interest, as the weather was probably nowhere more severe than in Hertfordshire, and the extreme care with which the observations are made render them of high value.

The minimum temperature registered 32° or below in January twenty-two days, February twenty-three days, March eighteen days, making a total of sixty-three days between January 3rd and March 18th. The temperature was below 20° on four days—January 7th and 8th (9°·2 and 7°·4), March 7th and 17th (18°·3 and 16°·9). The longest period with minimum temperature 32° or below was thirty-three days, from February 14th to March 18th; whilst on the grass frost occurred on seventy-three consecutive days, from January 5th to March 18th, with the solitary exception, if so it can be called, of 32°·1 on February 13th. The lowest temperatures on the grass or snow were: $-1°·6$ on January 7th, 0°·9 on January 8th, 13°·1 on February 10th, 10°·8 on March 7th, and 8°·9 on March 17th. The extreme variation of the temperature of the soil during the first seventeen days of March was, at 1 foot 0°·5,

from 32°·8 to 33°·3, and at 2 feet 0°·6, from 34°·5 to 35°·1. On March 13th the ground was frozen 6 ins. deep, or to a greater depth than at any previous time in the winter.

The days on which snow fell were :—January 5th, 6th, 8th, 10th, 12th, 17th, 19th, 21st, 22nd, 23rd, 24th, 25th, 29th ; February 3rd, 6th, 22nd, 23rd, 25th, 28th ; and March 1st, 2nd, 3rd, 6th, 12th, 13th, 14th, 15th, 16th, 18th.

More or less snow was always to be seen on the north sides of some few hedges between January 6th and March 19th, and, in connection with this, Mr. Mawley mentions that until March 1st there was no driving snow sufficient to form a snow-drift.

With the break up of the long frost the shade thermometer differed 40°·6 in fifty-three hours, from 16°·9, at 6 a.m. on the 17th, to 57°·5, at 11 a.m. on the 19th.

The unusual frequency with which snow fell throughout the period is a matter of great interest. The number of days on which it fell in January, February, and March is given in Table IV. The heaviest snowstorms throughout the winter were the storm of January 6th, which was about as heavy around London as in any part of the Kingdom, and the storm from February 28th to March 2nd. The latter was occasioned by a storm-centre advancing from the westward and crossing over central England. The heavy fall was doubtless largely due to the passage of the storm to the eastward being barred by an area of high barometric pressure. Snow was general over the whole country, and in most parts the storm was very severe, serious drifts being occasioned by the violent wind.

On February 28th and March 1st the fall of snow was heaviest over Wales and the southern and central parts of England, but in the north of England and in Scotland, and even in parts of Ireland, the full severity of the storm was experienced on March 1st and 2nd. The greatest violence of the storm was in the extreme north-east of England and in the south-east of Scotland.

The following are a few details of the storm, keeping as nearly as possible to order of date.

MARCH 1ST.

The heaviest snowstorm experienced for many years broke over Cheshire and North Wales in the early morning, and continued throughout the day.

Traffic was entirely suspended on the Bala and Festiniog line, the railway being blocked between Trawsfynydd and Arenig.

The line near Corwen, Merionethshire, was most completely blocked. The snow in the evening blocked the line to the depth of 8 or 10 feet.

The Cambrian line, between Oswestry and Welshpool, was blocked in several places, and a coast train was snowed up near Towyn, which was not dug out until the following day.

Two trains were snow-blocked in the Dolgelly district.

In the Isle of Man there were drifts on the high roads several yards deep. The railway line at Kirk Michael was completely blocked, and remained so on the 2nd, one train being entirely buried in a cutting all the time. The block still continued on the 3rd, when another snowstorm was experienced.

In the Barrow-in-Furness district the snow collected in immense drifts. The railway passenger traffic was completely disorganised and trains were embedded. It is over thirty years since a previous block was known on the Furness line.

In the Lake District snow fell all day, the snow drifted in many places to a great depth.

In the Settle district there was one of the most violent snowstorms experienced for many years. A block occurred on the line between Hawes Junction and Ribblehead. The line, which had been snow-blocked at Dent since 1st, was cleared for traffic on the morning of 4th.

At Birmingham the fall of snow was the heaviest that has been experienced this season. All the steam tram traffic was stopped, and the omnibuses did not run.

At Worcester the snowstorm was the most severe experienced this winter.

A train was snowed up between Watlington and Princes Risborough.

In Shropshire snow fell continuously for fifteen hours.

In North and West Lancashire the snowstorm was severe, in many places drifts were as high as the hedges and walls. In Preston snow accumulated 3 or 4 feet deep.

In East Yorkshire the snowstorm was the most severe of the winter, and huge drifts were formed. Serious interruption was caused to railway traffic, both on 1st and 2nd. The drifts on the Wolds were 12 feet deep.

The mail train from Whitehaven to Carnforth was snowed up near Ravenglass, the snow being from 5 to 6 feet deep.

Glasgow and the West of Scotland experienced a very heavy snowstorm apparently commencing in the evening (1st).

At Kirkwall snow fell very heavily.

An express train, which left London at 8 p.m., 1st, only reached Berwick the evening of 4th, having been embedded in the snow at Morpeth.

In the North of Ireland snow fell heavily all day. The evening mail train from Belfast to Londonderry was snowed up at Eglinton, about 7 miles from Londonderry. The snowstorm continued in Belfast on 2nd, and lasted for close upon forty-eight hours.

MARCH 2ND.

Snow fell heavily all over Cheshire and North Wales.

Several blocks occurred on the East Lancashire railway system..

There was a great block between Preston and Lancaster, on the London and North-western system. The snow, which was from 4 to 5 feet deep in the fields, was blown into the cuttings, and a train near Scorton became embedded in a drift over 4 yards deep.

Between Redcar and Saltburn the railway was blocked by drifting snow. A passenger train from Darlington ran into the drift and remained fast.

The line at Huntcliffe, between Brotton and Loftus, was completely blocked, and two trains were embedded in the snow.

Between Sunderland and Cleadon three trains were partly buried in the snow.

At Edinburgh the railway traffic was completely disorganised.

Railway communication was completely stopped on the St. Andrew's line after midday. On other portions of the Fifeshire Railway system trains were snowed up during the day. The snowstorm abated during the night, but the accumulation of snow did not allow of communication with the main line until after midday of 3rd.

On the Caledonian Railway there was a complete stoppage of traffic for several hours.

The North British Railway was completely blocked. A train stuck in a snow drift near Arbroath, and a goods train got embedded near the same place. Two Caledonian trains were snow-bound between Montrose and Dubton.

In the Isle of Man another snowstorm was experienced with a bitter North-east wind.

MARCH 3RD.

The two trains which were embedded since the night of 2nd in the snow between Sunderland and Newcastle, were dug out at about 4 p.m. (3rd), and the line was partially opened.

At Hartlepool the snowstorm continued throughout the night of 2nd and part of 3rd.

The Midland line between Leicester and Carlisle was partially cleared. Not a single Scotch express had reached Leicester during the day. Five miles from Kirkby Stephen there were, at night, trains still embedded in the snow which were blocked on the North Eastern line on the night of the 1st.

A further fall of snow was experienced in Cumberland, Westmoreland and North Yorkshire.

Snow fell at intervals over North Wales, drifting many yards deep on the mountain ranges.

MARCH 5TH.

A very heavy snowstorm was experienced in Devonshire, Somersetshire, Dorsetshire and Sussex. At Brighton the ground was covered to the depth of several inches.

Mr. P. Bicknell, F.R.Met.Soc., has kindly supplied the following details with regard to the ice, and a list of the days' skating enjoyed by the London Skating Club, during the principal winters since its formation in 1830.

TABLE VII.

LONDON SKATING CLUB.—YEARS HAVING 18 DAYS AND UPWARDS OF SKATING.

Year.	Dec.	Jan.	Feb.	Mar.	Total Days.	Year.	Dec.	Jan.	Feb.	Mar.	Total Days.
	Days.	Days.	Days.	Days.			Days.	Days.	Days.	Days.	
1830–31	5	11	4	...	20	1860–61	9	23	...	...	32
1837–38	...	20	17	...	37	1869–70	2	4	13	...	19
1840–41	5	16	10	...	31	1870–71	8	20	1	...	29
1841–42	1	17	...	...	18	1878–79	15	25	6	...	46
1844–45	15	...	14	12	41	1879–80	28	12	7	...	47
1846–47	11	14	4	...	29	1880–81	...	18	1	...	19
1849–50	3	23	...	...	26	1885–86	3	13	6	16	38
1854–55	...	10	18	...	28						

All of eighteen days and over are included, selecting that figure because it is divided by a decided gap from the next figures, viz. fourteen days in 1857-8, thirteen days in 1853-4 and 1875-6, and twelve days in 1866-7 and 1874-5. The only Club record of skating in November is two days (23rd and 24th) in 1858, but there was skating in Bushey Park on November 16th, 1879. The only March records in the fifty-six years are those (1845 and 1886) given in the list, one day in 1853, and ten days in 1858. 1885-86 is the only occasion of skating in all the four months—December to March.

Mr. Bicknell states that it is extremely difficult, from a skater's point of view, to compare the last winter with the others, as the amount of skating varied so strangely in different places not far apart. On a pond (Captain Edwards') at Pinner there was almost continuous skating for three months, and at Rickmansworth for about seventy days; but at both places the ice was most carefully nursed—the snow kept swept, and skating was stopped in the middle of the day when desirable.

He gives the following temperatures from his Beckenham record as most remarkable:—

1886.	9 a.m.	Min.	Max.	Mean.
January 6	**32°·5**	**31°·8**	**33°**	**32°·4**

Snow from about 5 a.m. till 1.30 p.m. · Frost at night.

Melted snow gauged January 5th 0·441 in.; January 6th 0·165 in.

	9 a.m.	Min.
January 7	**25°·8**	**21°·5**

Safe skating on snow ice after one frost of only 10°.

During the March frost, the ice here (at Beckenham) steadily *disappeared* under the influence of the NE winds, and there was hardly any—no good skating round here, though we had 16 days at the Club in the heart of London!

Mr. W. P. Warner, of the Welsh Harp Fishery, at Hendon, states that skating there commenced on January 9th, with a splendid sheet of ice, but it only lasted three days; the ice with this frost was 2¼ ins. in thickness. Skating was recommenced on February 9th, but it only lasted three days. On March 7th there was again skating, and from this time it was indulged in daily until the 18th. The greatest thickness of the ice was 5 inches.

Mr. H. Ingate Warren, Hon. Sec. of the Crystal Palace Skating Club, gives the following list of days on which skating took place on the Club water.

1885. December 12th, 13th. 1886. January 9th, 10th, 11th, 20th, 21st, 22nd, 23rd; February 8th, 9th, 10th, 11th, 15th, 27th; and March 1st, 2nd, 7th, 8th.

He adds that skating continued on other waters in the Crystal Palace Grounds till about March 14th or 15th, but owing to some curious air currents, the ice on the Club water was broken up.

The ice in many of the public parks in the Metropolis was exceedingly good, and as late as March 17th the ice on the Serpentine, Hyde Park, was in splendid condition, and fully 10,000 persons were skating and sliding during the day.

An examination has been made of the temperature of the water of the Thames as observed at Deptford each day during the three months January to March 1886, and a comparison made with the air temperature observed at Greenwich. The observations for this comparison were obtained from the *Registrar General's Returns*. The range of the water temperature, as shown by the highest and lowest readings recorded each day, were—

		°		°
January	Highest	43·8	Lowest	34·0
February	„	39·1	„	35·0
March	„	50·7	„	35·0

From January 8th to March 20th the entire range was from 40° to 34°, and from March 1st to 19th the whole range was between 36°·5 and 35°.

The monthly means were:—

		°		°
January	Water	36·8	Air	36·1
February	„	36·9	„	33·7
March	„	39·5	„	39·6

On comparing these results with a discussion for the years 1845 to 1879, except 1857 and 1870, by Sir G. B. Airy,[1] the following instances are obtained of lower water temperatures in the several months.

[1] *Proceedings of the Royal Society*, Vol. XXXIV.

n. 1850, 33°·0; 1879, 33°·9; 1861, 35°·0; 1867, 35°·1; 1871, 35°·9; 1845, 34°·4; 1855, 34°·6; 1878, 36°·6. Mar. 1845, 33°·8.

e rapid way in which the Thames water took up the sudden change in ir temperature in the latter part of March 1886 is very striking.

e Society's records of earth temperature have been examined, and twelve ns have been selected as fairly representative of England. The results hese from January 1st to March 17th are given in Table VIII. Mr. iott has furnished me with the averages for 1881 to 1885, which enables nparison to be made with the several means.

TABLE VIII.

EARTH TEMPERATURES.

Station.	1 Foot.								
	Mean.			Diff. from Air Temp.			Defect from Average, 1881–85.		
	Jan.	Feb.	Mar. 1–17.	Jan.	Feb.	Mar. 1–17.	Jan.	Feb.	Mar. 1–17.
	°	°	°	°	°	°	°	°	°
rton Reigny ..	35.3	34.2	33.3	+2.6	+1.3	+3.4	..	..	..
nton	35.5	35.2	34.3	+1.8	+1.3	+3.5	..	..	..
lsock	36.2	35.7	34.8	+1.7	+1.4	+5.2	..	..	..
restoft	36.9	35.3	34.7	+0.6	+1.2	+1.1	1.9	4.8	6.3
ley Guise	34.7	33.8	32.9	+0.8	+1.7	+2.0	2.9	5.6	7.8
diff	38.8	38.1	35.8	+1.8	+2.5	+1.8	2.4	4.5	7.0
wood	35.7	33.7	32.5	−0.2	−0.1	+0.1	3.0	6.4	8.5
gate	37.9	36.6	34.9	+1.2	+1.4	+1.2	..	..	..
estock	37.0	35.8	34.1	+1.3	+1.9	+1.2	..	..	..
well	37.8	36.9	35.0	+1.2	+2.9	+2.7	..	..	..
lompton	37.8	37.6	36.3	+1.0	+2.4	+2.6	2.9	4.8	7.0
bacombe	39.5	39.2	37.9	+1.0	+1.5	+2.6	2.9	4.8	7.1

tation.	1 Foot.						2 Feet.								
	Extremes.						Excess on 1 Foot.			Extremes.					
	Jan.		Feb.		Mar. 1–17.					Jan.		Feb.		Mar. 1–17.	
	Highest.	Lowest.	Highest.	Lowest.	Highest.	Lowest.	January.	February.	March 1–17.	Highest.	Lowest.	Highest.	Lowest.	Highest.	Lowest.
	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°
on Reigny	41.5	33.8	35.5	33.8	33.8	32.9	1.7	1.2	1.5	40.5	35.5	36.0	35.0	35.0	34.3
ton	40.5	34.0	37.5	34.0	35.3	33.7	..	..	..	..	..	..	..	..	..
ock	42.0	34.4	38.7	34.3	36.2	34.0	..	..	..	..	..	..	..	..	..
stoft	42.0	34.5	37.1	34.0	35.0	34.5	0.9	0.2	0.2	42.0	35.4	36.6	34.5	35.4	34.7
ey Guise	41.5	33.3	36.1	33.0	33.0	32.7	2.5	2.1	1.8	41.2	35.7	36.9	35.2	35.2	33.3
iff	44.2	36.1	41.0	36.6	36.8	35.2	..	..	..	..	..	..	..	..	..
ood	41.5	33.6	34.8	32.8	32.9	32.1	..	..	..	..	..	..	..	..	..
ate	44.2	35.1	39.4	34.8	35.6	34.1	2.3	2.1	2.5	44.2	38.2	39.6	37.8	38.2	36.8
stock	42.3	34.5	37.5	34.3	34.9	33.5	2.0	1.7	2.0	42.3	37.0	38.3	36.8	36.7	35.6
ell	43.5	35.3	39.5	35.2	36.3	34.2	..	..	..	..	..	..	..	..	..
mpton ..	43.8	34.8	41.0	35.8	37.4	35.3	..	..	..	..	..	..	..	..	..
acombe	45.3	35.7	42.3	37.5	39.9	37.1	..	..	..	..	..	..	..	..	..

e Table shows that at 1 foot below the surface, the greatest cold for the r was reached during the first seventeen days of March. The lowest

mean was 32°·5 at Norwood. The mean temperature of the soil at 1 foot below the surface was generally about 2° in excess of the mean air temperature. Norwood, however, is a marked exception to this, the temperature at 1 foot being in good agreement with that of the air. In January, the earth temperature at 1 foot was from 2° to 3° below the average over the whole country, whilst in February it was from 4°·5 to 6°·5 below the average. The first seventeen days of March, however, show a much larger defect on the average, the deficiency ranging from 6°·3 at Lowestoft to 8°·5 at Norwood. The absolute range of temperature was generally much less from March 1st to 17th than in January or February. At Norwood, the temperature at 1 foot was below 33° from March 1st to 19th, but it did not fall lower than 32°·1. The temperature of the soil at 2 feet was generally about 2° in excess of that at 1 foot, but at Lowestoft the excess from February 1st to March 17th only amounted to 0°·2.

All of these facts show that the recent winter was one of the longest experienced for a long series of years, and in many ways it may be characterised as most severe.

A very cursory examination of the ships' logs received by the Meteorological Office tends to show that the abnormal conditions which prevailed over the British Islands, and, indeed, over nearly the whole of Europe, extended also a considerable distance to the westward. Ships traversing the North Atlantic observed a decided tendency to a low barometer in the early months of 1886 in the locality where a high barometer generally prevails, and to the north of this low barometer, which seemed of a permanent character, strong and persistent Easterly winds were experienced. The principal Lightkeeper at Cay Sal, who spent the winter at Elbow Cays, states that the winter was very cold—the coldest that the oldest inhabitant ever knew, and he believes the winter was the coldest known for a long time in the Bahamas. In Cumberland Sound, Davis Straits, the winter was stated to be the coldest experienced in the last eight years; and reports from Spitzbergen also show that the winter was exceptionally severe. These facts tend to show a general reversal of conditions over a great part of the Northern Hemisphere, and doubtless would be very intimately related to our own exceptional weather.

In conclusion, I have to thank the Meteorological Council for having so kindly placed the whole of their material at my disposal for the compilation of this paper, and I would also thank the Society for the use of its returns, and Mr. Marriott for the ready assistance afforded. Mr. Symons and others have also helped me considerably by contributions of material.

DISCUSSION.

Dr. Tripe said that Mr. Harding had contributed a very useful paper, not only as affording a means of comparison with other severe winters, but also as regards the effects of cold on vegetation and on man. He was surprised the other day to see a number of double fuchsias and other comparatively tender plants throwing out shoots. The effects on man, with the exception of one or two weeks, were not so marked as in some other severe winters, in which a lower temperature and greater range had occurred.

Mr. Laughton hoped that Mr. Harding would be able to add to his very inter-

esting paper some notice of the remarkable extension of this protracted winter into May: an extension which, in the last week (May 11th-15th), had buried the North of England in snow, and put a great part of the Midland Counties under water.

Mr. Baldwin Latham said that from his own observations it was clear that the past winter had not been so severe as that of 1881. The experience of the past winter showed that a long winter was much more injurious to vegetation than a sharp but short one like that of 1881. A passion flower, which grew in front of his house at Croydon, was killed in the last winter, although it survived the winter of 1881, and a similar plant in the same position was killed in the winter of 1879. It was curious to note at the present time, in spite of the past prolonged winter, the temperature of the ground at a depth of 2 ft. 6 ins. was higher than it had been for some years past, and which, in a great measure, accounted for the very rapid progress made by vegetation after the extremely cold weather of March last.

Mr. Dymond said that although seeds lying in the ground, and deciduous plants, such as fuchsias, had, no doubt, not suffered to any great extent, evergreen shrubs, usually hardy, had been very severely nipped by the long continued cold. He had had laurustinas and similar shrubs greatly damaged, and in some cases killed down.

Mr. C. O. Budd remarked that the weather in Italy during the winter had been of a most exceptional character, and seemed to have very much resembled that experienced in this country. The early part of March was cold, but the latter half was fine. The spring was backward: on leaving the neighbourhood of Naples in May, the season was considered three weeks late.

Mr. Mawley said that, as regards the comparatively little injury done to vegetation by the cold of last winter, and also with regard to the temperature of the ground at the present time, it should not be forgotten that during the keenest frosts the ground was thickly covered with snow. At the same time, however, he was greatly surprised to find, when pruning his roses in March, that the wood of many of the hardier varieties was quite sound almost to the tips of the shoots. He had expected to find out at once, through the discoloration of the pith, the exact height to which the snow had covered the plants, but this he had been unable to do, notwithstanding that the upper parts of these roses had been exposed on one night to a temperature below zero. In less severe winters he had known the shoots of his roses more seriously injured than they had been last winter. On the other hand, about half the gorse on Berkhamsted Common, which was situated high above the town, had been killed to the ground. The destruction of this latter was, however, no doubt as much due to the snow as to the cold.

Mr. Hawes exhibited a diagram showing the number of days of skating on ponds at Weybridge, and gave some particulars respecting the condition of the ice. There were in all sixty-seven days' skating recorded between November and March.

Mr. Gaster said that there were three distributions of barometric pressure common to the winter months which produce cold weather: first, when the pressure is high to the North of our Islands and low to the South; second, when the centre of an anticyclone lies over the central parts of the British Islands; and third, when an anticyclone lies to the Eastward of, but partly overlapping, these Islands. This last condition was that which obtained during the past winter, and gave such a long spell of cold weather without any very great extremes being recorded. With this distribution of pressure, Easterly winds are drawn from the Continent across our Islands to the Atlantic, bringing with them the low temperature of the region whence they are drawn. There are no means of ascertaining the distribution of pressure during some of the cold periods in the years long gone by referred to by Mr. Harding, otherwise an interesting comparison could be made and some valuable results obtained. In the case of the severe weather of January 1881 the second condition of pressure prevailed, and a study of these pressure distributions would explain the different degree of intensity of cold experienced in the two winters. With respect to the bad weather prevailing during the past few days, referred to by Mr. Laughton, he remarked that when there were two anticyclonic areas, one lying to the northward of the other, the weather in the trough between the two systems was invariably of a most unsettled, rainy, thundery, and uncomfortable nature.

Mr. SCOTT stated that he remembered reading in Evelyn's Diary that at the close of the seventeenth century a succession of very late springs were recorded. (See note.[1])

Mr. SOUTHALL said that the floods in the Wye and Severn had never before been known to be so great in May as during the past week.

Mr. SYMONS said that in the West of England the present floods were almost without a parallel. At dry stations in Shropshire, upwards of 6¼ ins. of rain had fallen in 2¼ days.

Mr. LAUGHTON said that in the Trent valley the floods were very wide-spread; and he had been told in the neighbourhood of Retford that they were higher than any experienced during the last forty-five years.

Mr. SYMONS remarked that he believed at several places 1790 was the only year in which the floods equalled the present.

Dr. MARCET said that he had noticed that the hawthorn was very late in coming out this year. He also drew attention to the daily change which took place in the state of the ice in March; while in the morning it would frequently be bearing well, by noon it became unsafe, assuming the colloid state described by Graham, and generally known as "rotten."

[1] "1688, April 29. The weather was till now so cold and sharp, by an almost perpetual East wind which had continued many monthes, that there was little appearance of any spring, yet the winter was very favourable as to frost and snow."
"1692, April 24. Very cold and unseasonable weather, scarce a leaf on the trees."
"1695, April 21. The spring begins to appear, yet the trees hardly leafed."
"1698, May 8. An extraordinary great snow and frost, nipping the corn and other fruits."

DESCRIPTION OF AN ALTAZIMUTH ANEMOMETER FOR CONTINUOUSLY RECORDING THE VERTICAL ANGLE AS WELL AS THE HORIZONTAL DIRECTION AND FORCE OF THE WIND. By LOUIS MARINO CASELLA. (Communicated by L. P. CASELLA, F.R.Met.Soc., F.R.A.S.)

[Read May 19th, 1886.]

IT appears unnecessary to dwell at length on the existence of air currents moving in a direction more or less inclined to the plane of the horizon, for to any one at all acquainted with meteorology they must be an accepted, if not a self-evident, fact.

Irrespective of the inclination to the horizontal plane of the greater air currents, such as those shown upon Maury's well-known diagram, it is evident that the irregularities of surface, in all but the most extensive plains, will tend to throw air currents into motions more or less inclined to the plane of the horizon. But most of all is it evident that observatories and other buildings are certain to affect air currents both horizontally and vertically, so that probably scarcely any pressure plate yet erected has experienced a wind at right angles to its surface.

The existence of currents inclined to the plane of the horizon (which will for the future be spoken of simply as inclined currents) being conceded, the necessity for the study of their inclination and velocity is at once apparent, inasmuch as the primary object of meteorologists in studying the direction and motion of the wind is to arrive at the laws which govern the circulation of the air by ascertaining the quantities which pass over and away from fixed points.

The fact of the existence of such currents having been recognised by meteorologists for, at any rate, a considerable number of years, it appears remarkable that little or no discussion of the subject has taken place at the International Meteorological Congresses, but such is believed to be the case; the matter was referred to at Rome in 1879, by Professor Plantamour and Dr. Wild, but was scarcely considered.

The instruments chiefly used for measuring the velocity and force of the wind are Robinson's Cup Anemometer and Wild's Swinging Pressure Plate; there are also some of Osler's Pressure Anemometers and similar instruments in use, but the number is comparatively small.

Robinson's Anemometer, although it receives the true horizontal component of the wind whether the currents are ascending or descending, is unsatisfactory, inasmuch as its co-efficient has not been definitely settled, and apparently varies with the length of arm and size of cup; nevertheless, no fixed rule of construction has been adopted, and the instruments in use vary indefinitely in both particulars, with the results that their indications are not comparable *inter se.*

Wild's Pressure Plates, although more comparable one with another, are open to a different objection. The plate being pivoted at the top, presents a varying angle to the wind when inclined from the vertical, with the result that while an ascending current will strike it at a right angle a descending current will meet it at a very acute angle.

It is impossible to say at what date the inclination of the air currents was first considered; but more than 100 years ago an anemometer for indicating inclination currents was designed, and several have been described since. Mr. J. K. Laughton, in his *Historical Sketch of Anemometry and Anemometers,*[1] mentions the following instruments designed to indicate inclination currents, and gives references to the works in which they are described and the dates at which the descriptions were published; there is, however, no proof that these anemometers were all practically tried or even constructed:—

Date.	Inventor.	Where described.
1781.	Dalberg.	*Rozier, Observations sur la Physique,* Vol. XVII. p. 488.
1801.	Benzenberg.	*Gilbert's Annalen,* Vol. VIII. p 240.
1840.	Cacciatore.	*Annuario della Società Meteorologica Italiana,* Vol. I. p. 201.
?1855.	Dollond.	
1856.	Hennessy.	*Brit. Ass. Rep.* 1856, Part II. p. 40; and 1857, Part II. p. 80.
1881.	Dechevrens.	*Sur l'Inclinaison des Vents* (Observatory of Zi-Ka-Wei).

With the exception of the last of these nearly all exhibited merely the inclination of the currents from moment to moment, and did not give a continuous record; but Dechevrens', the most recent, although indicating

[1] *Quarterly Journal,* Vol. VIII. p. 161,

only the horizontal and vertical directions of the wind, and taking no account of its velocity or force, is self-recording and is worthy of a short description.

A balanced double vane, *i.e.* a vane with both vertical and horizontal plates, is mounted on a horizontal axis, supported by a copper stirrup, soldered to the extremity of a tubular shaft which descends into the Observatory. At the lower end of this shaft is a zinc cylinder floating in a vessel of water and glycerine; this cylinder supports the shaft, vane, driving clock and drum for recording the inclination of the air currents, and being unattached to the vessel in which it floats, turns freely with every direction of the vane. Attached to the axis on which the vane swings is a grooved pulley, over which passes a light chain, one end of which is fixed to the pulley and the other end passes down the vertical shaft to the top of the zinc float, where it gives motion to a light metallic lever which traverses the shaft by two longitudinal slits; this lever carries a pencil which traces an arc of a circle on a cylinder driven by a clock. The whole of this apparatus being, as before mentioned, carried by the float, turns with it as the wind shifts. The horizontal direction of the wind is recorded on a separate sheet. On the vertical shaft carrying the vane there is a fixed toothed wheel, which engages with a similar toothed wheel fixed to a paper covered cylinder; this cylinder, therefore, turns to the same extent as the vane, but in an opposite direction; a pencil is drawn along it by a clock, and the position of the pencil mark on the paper indicates the direction of the wind at any moment.[1]

This instrument appears to be of a rather elementary description and somewhat incomplete, inasmuch as it records neither the velocity nor the pressure of the wind; and although the indication of the inclination is all that could be desired, the method of obtaining the horizontal direction by carrying the whole apparatus on a float seems unsatisfactory, and the amount of work thrown on the vane must be very great.

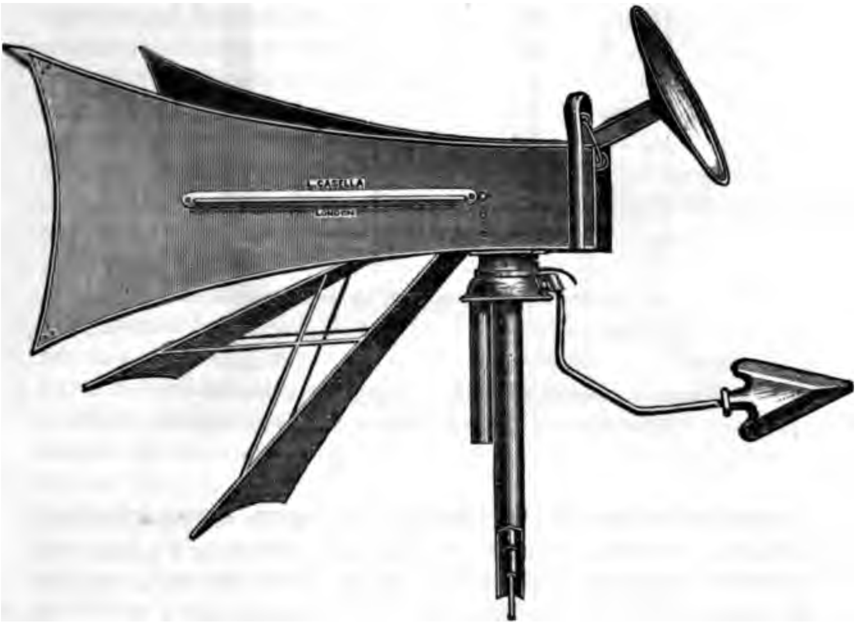
As so frequently happens, one inventor works without knowing what his predecessors have done, so, until my anemometer was completed, I had no idea that any instrument had been constructed for indicating the inclination of air currents. The anemometer which I have designed and constructed, and now have the honour of exhibiting to the Royal Meteorological Society, differs in nearly every respect from that of Dechevrens and all the others of which I have heard, recording continuously on one sheet of paper the pressure, direction and inclination of the wind with all its changes, the pressure plate being always maintained truly at a right angle to the wind. I have adopted a record of pressure, in preference to one of velocity, for the reason mentioned before, viz. the uncertainty attaching to the indications of Robinson's cups or any other description of fan, inasmuch as the co-efficient of such cups or fans has not been satisfactorily ascertained.

[1] Dechevrens in his pamphlet (*Sur l'Inclinaison des Vents*, Chang-hai, 4to. 1881) figures also a vane of this description, with a set of Robinson's cups attached to it, but does not describe it or suggest any method of recording its indications.

In this description the three records will be dealt with separately and somewhat generally, a detailed account being given in the specification of the patent.[1]

The apparatus for indicating the direction of the wind consists of a vane (Fig. 1.) constructed of a pair of diverging blades fixed to a cap, mounted so as to rotate about a vertical axis, the motion of this vane being transmitted by a vertical tubular shaft passing downwards through the usual fixed column to the registering mechanism. This tubular shaft, called the direction tube,

FIG. 1.

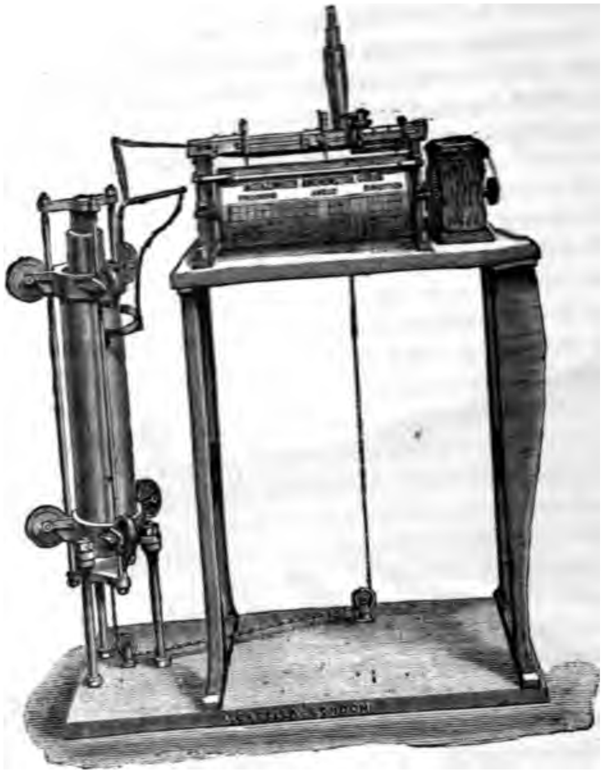


is made to operate the styles which record its movements through the medium of pinions and wheels, conveying motion to two discs, which are made to carry pencils in a vertical position and equi-distant; three styles are used, so that one is always ready to enter on the scale at one side when another leaves it at the other side. (Fig. 2, p. 250.)

The apparatus for indicating the inclination of the wind, that is, its divergence from a horizontal plane, consists of a similar vane (composed of a pair

[1] Specification of Louis Marino Casella. Apparatus for indicating and recording the pressure and direction of the Wind, A.D. 1882, 30th December, No. 6240.

FIG. 2.



of diverging blades), mounted on a horizontal axis within the direction-vane, so balanced as to assume normally, when no wind is blowing, a position in which its longitudinal axis is horizontal. To insure this, the vane is brought to a condition of stable equilibrium as closely approximating to that of instability as it is possible to bring it.

The oscillating motion of this inclination vane is transmitted to its registering mechanism by a tubular connecting rod, jointed to the vane by a pair of links, which move up and down inside the direction tube; the inclination tube is so connected with the carriage of a style. Thus its longitudinal motion only affects the latter, which thus records upon the scale the oscillations of the vane due to the varying inclination of the wind.

The pressure plate is a disc having an area of $1\frac{1}{2}$ square feet fixed to a guide rod, fitted to slide between pairs of guide rollers in the frame of the inclination vane, and moving with it. This plate should have had a cone at the back, which was omitted in its construction. In order to prevent the varying positions of the pressure plate affecting the balance of the vane, its motion is constantly and exactly compensated by a moveable weight running

n rollers, so arranged that the weight moves to a proportionate extent in 1e opposite direction to the pressure plate, so as to maintain the balance of 1e vane in all positions of the pressure plate. The motion of the pressure late is transmitted to the apparatus for measuring the force by means of a hain attached to the guide rod of the plate, and passing down over a pulley hrough the tubular shaft of the inclination vane. To prevent the weight of his chain affecting the accuracy of the records, it is exactly balanced by a ounterpoise hanging in a casing carried by the cap. In this way the pres-ure plate is kept perpendicular to the direction of the air current, not only n azimuth but also in altitude.

The apparatus for measuring the pressure consists of a cistern containing nercury and a displacement plunger immersed therein, connected to a frame of guide rods joined together above and below the mercury cistern, which vorks up and down against guide wheels mounted around the cistern, the :hain being attached to the bottom of the frame. The plunger has a varying 'atio of displacement for successive depths of immersion, so that the scale nay be open for the smaller and compressed for the greater (and less frequent))ressures. In order to check the motion of the plunger and avoid inaccuracy n the indications, due to the momentum of the parts, the lower end of the)lunger is provided with a disc fitting more or less closely to the sides of the nercury cistern, so as to prevent the too rapid passage of the mercury from one side of the disc to the other. Great care and consideration have been levoted to this part of the mechanism, the most suitable size for the disc eing decided by actual experiment, so that, while the evils due to momentum re avoided, the registration is not rendered at all sluggish, the pencil in the nstrument exhibited returning to zero in three seconds after displacement.

The frame is connected to the carriage of the marker for registering the notions of the plunger by means of a bell-crank lever. The carriage carrying he recording pencil is mounted to travel upon rollers running upon the)ppositely bevilled edges of a horizontal bar and rollers running on the ront and back surfaces, by which it is truly guided with the least possible riction. The markers are all metallic, sliding in sockets and pressing by their own weight or by springs on the paper. The scales for the different records are marked upon a single sheet of paper wrapped round a cylinder, rotated at a uniform speed by a clock movement in the usual manner.

Throughout the whole apparatus the greatest care has been devoted to the construction, so that friction is reduced to a minimum, almost all moving surfaces running on rollers; at the same time all the moving parts are carefully counterbalanced by moving weights, so that, no matter to what extent they may vary from their normal position, they are always truly balanced.

The plunger in a cistern of mercury for receiving the pressure of the wind acts with perfect success, and obviates the well-known difficulties attaching to springs on account of their varying elasticity, which is affected by the constant changes of temperature, and also their gradual deterioration; weights also are unsatisfactory, as it is almost impossible to overcome their momen-

, which, in gusty weather especially, has a tendency to exaggerate the ›rd both of the force of the wind during gusts and its diminution during ›s.

The apparatus has been in action for about six months, mounted on the of of a building in Holborn about 80 feet above the ground and 20 feet ›ove the roofs of the houses. Several of the record sheets are exhibited to ›e meeting.

As would naturally be expected in such a position, the inclination from the ›orizontal plane is very great and varies rapidly and frequently, while at the same time the records of pressure are in all probability too small.

DISCUSSION.

Mr. LAUGHTON thought that the register of inclined pressure shown by this instrument might give a false idea of force of wind, especially in the case of anemometers placed on high buildings; for their records would indicate the upward force of the accumulation of air against the wall of the building. In his opinion the proper position for anemometers was on the top of a pole in an open plain. He asked if Mr. Casella had any reason for making the pressure plate one foot and a half in area, as pressures are generally quoted in pounds per square foot, and, as existing observations do not show that the pressure on one square foot is ⅔rds of that on a foot and a half, it seemed almost a pity that the size of the plate had not been restricted to the unit of measurement.

Mr. STANLEY said that some years ago he constructed a vane for the purpose of testing the angle of the wind's inclination. This vane was made in such a manner that, if necessary, it could turn completely over. The indications of this instrument were observed for some time, and he had found it often showed an inclination of 30° or 40°, and frequently toppled right round. Mr. Casella's plan of the plunging rod in mercury he had himself patented as a part of an instrument in 1872, but he was sure that Mr. Casella had re-invented this plan.

Mr. SCOTT stated that at the International Meteorological Congress of Vienna, in 1873, the late Prof. Donati announced that he had constructed a wind vane to show the direction of the wind in altitude and azimuth (*Vide Report of the Congress of Vienna*, p. 18).

Mr. RAMSAY inquired whether a description could be found anywhere of the instrument used by Prof. Hennessy in his experiments on the inclination of winds, which were embodied in a paper read before the British Association.

Mr. SYMONS said that Mr. Laughton's criticisms of the indications afforded by this instrument were equally applicable to most of the anemometers erected. He thought it was extremely important that the vertical component of the wind force should be registered. The novelty of Mr. Casella's instrument was that all three elements, direction, pressure, and inclination, were recorded by it simultaneously.

Mr. J. S. HARDING said that the Fellows might be interested to know that in the last published number of the *Bollettino Mensuale della Società Meteorologica Italiana* (for February 1886) there was a description of a "Modification of Denza's Anemograph, for obtaining the direction of oblique winds, and for obtaining greater sensibility in Robinson's Windmill-vane," by F. Cravero. The tail of the wind-vane is formed of a hollow cone, around which are soldered four valves, arranged in the vertical and horizontal planes. The arrow-head has a counterpoise which keeps the vane in equilibrium when there is no wind. The anemometer records both the direction of the wind and its inclination upon the same paper, both being traced continuously by two pencils. The angle of the wind's obliquity is easily calculated from the trace, as this occupies a place to the left or right of a zero line on the paper, according as the axis of the vane is inclined below or above the horizontal. The article is accompanied by plates illustrating the working of the anemometer.

Mr. ARCHIBALD said he had found, in the course of his experiments with kites, that they rose higher with some winds than with others. For instance, he had

ticed that the kite rose higher in West winds than in North-east or East winds owing with equal force. He supposed this must be due to inclination, some inds having a downward tendency. His kites rose best with North-west winds. e thought that anemometers should be placed much higher than they usually e. In going through some volumes of meteorological observations made in dia, he had found that although the anemometers were placed at heights varyg from 5 to 70 ft. the observations were treated as being of equal value. It as very desirable that the International Committee should settle upon an iform height for the erection of anemometers.

Mr. SOUTHALL said he was about to erect a vane, and should very much like to 1ow the most suitable elevation at which it should be placed.

Mr. LECKY said there were many good points about Mr. Casella's instrument, id it was a distinct advance in the right direction.

Mr. W. H. DINES thought that it was more important that anemometers should placed in a position free from the eddies of trees and buildings, than that they ould all be placed at the same absolute height above the ground. From some ugh experiments which he had made, he believed that an anemometer would be und in many cases to show from thirty to fifty per cent. more wind when aced 10 feet above the roof of a house than when placed 20 feet above the me house. He also thought inclined currents must be quite local, for an ward current could not exist over an extensive area without very quickly hausting the air from the centre at least of such area, a phenomena which rtainly did not occur.

Mr. L. P. CASELLA, replying on behalf of his son, who was unavoidably absent, id that in considering the question of anemometers and their indications it was ways desirable to remember to what uses the indications of the instrument ere to be applied, whether for engineering purposes or for meteorological irposes alone, to both of which the present one was equally adapted, whether indicating the angle direction and force of the gust that blew down the ay Bridge, or direction and power of the wind at the higher altitudes attained the kite to which Mr. Archibald had referred, as such considerations must be ealt with in placing the instrument as well as in reading its indications. Rearding the size of the plate, he believed that it was not necessary that it should limited to 1½ foot in area. The plunging rod arrangement had been adopted preference to springs, which were liable to corrosion, and also because the dications could be registered with greater ease and certainty by using mercury the manner adopted in this instrument.

ARTH TEMPERATURES, 1881-1885. By WILLIAM MARRIOTT, F.R.Met.Soc., Assistant-Secretary.

[Read May 19th, 1886.]

BSERVATIONS of the temperature of the soil at various depths below the irface have been regularly made at several of the Society's stations during he past five years. I beg to submit the results of these observations, and lso of those from other stations where observations have been made during ny part of the lustrum 1881-1885.

The observations have in almost all cases been made with Symons's Earth 'hermometer. The apparatus consists of an iron pipe driven into the round to the required depth, and a small but strong thermometer, the bulb f which is so protected that no change of indication occurs when the ther-iometer is drawn out of the tube for reading. The pipe is closed at the ottom by welding, and the point hardened so as to penetrate the soil with ase and to keep it water tight. For depths under two feet the thermo-

meter is inserted in a light rod, but for all greater depths it is mounted in a short weighted stick attached to a strong chain. The top of the pipe is closed with a tight fitting brass cap.

The instruments are placed beneath the soil in open situations, and are in all cases under grass, though at some of the stations the grass extends only a short distance from the instruments.

Observations have been made at the depth of 3 inches at two stations; at 6 inches at five stations; at 1 foot at twenty stations; at 1½ foot at one station; at 2 feet at eight stations; at 3 feet at one station; and at 4 feet at six stations.

The readings have been taken once daily, viz. at 9 a.m.

Table I. gives the mean temperature of the soil at the various depths for each month and for the year, together with the highest and lowest observed readings and the dates of their occurrence during each year.

As the observations are only taken at 9 a.m., no information can be obtained as to the character and amount of the diurnal variation of temperature at the various depths beneath the soil. Some years ago Mr. Symons discussed the observations made at the Royal Botanic Society's Gardens, Regent's Park, during the six years 1871-76, and found that the results for July showed "that the temperature of the soil, 3 inches deep, rises from 64°·9 to 75° between 9 a.m. and 3 p.m., falls from 75° to 67°·2 by 9 p.m., and probably still lower during the night, rising again to 64°·9 by 9 a.m. the next day. The 6 inch thermometer shows similar changes but to a lesser extent, and as the 9 p.m. temperature is 4°·9 above that at 9 a.m. it is evident that both the minimum and maximum temperatures occur considerably later in the day than at 3 inches below the surface. The 1 foot thermometer shows 2°·8 difference between 9 a.m. and 9 p.m., and an exactly intermediate reading at 3 p.m.; it is therefore probable that the soil at a depth of 1 foot is coldest at 9 a.m. and hottest (not at midday) but at 9 p.m. At 2 feet below the ground the temperature at the three observation hours only differs by 0°·1, being identical at 9 a.m. and 3 p.m., and 0°·1 colder at 9 p.m. The 4 feet thermometer shows no difference whatever. In winter these daily ranges are of course very much smaller, in fact, scarcely one-tenth of what they are in July."

Table II. gives the mean monthly and annual temperature of the soil for the five years 1881-85 for such stations as are complete for that period.

Table III. gives the mean monthly and annual temperature of the air (mean of maximum and minimum) for the same stations during the same period.

On comparing the results in these Tables it will be seen that the temperature of the soil at 1 foot at nearly all the stations in the winter months is almost the same as that of the air, while in the other months of the year the temperature of the soil is higher than that of the air at all except the London stations. This is no doubt due to the fact that in winter there is but little power in the sun's rays to affect the temperature of the soil, while in the other months of the year, as the sun rises earlier, he has greater power to

TABLE I.

MEAN TEMPERATURE OF THE SOIL FOR EACH MONTH, 1881–85

Station, Authority, and Height above Sea Level.	Years.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Mean.	Extreme Readings. Highest.	Date.	Lowest.	Date.
3 Ins.		°	°	°	°	°	°	°	°	°	°	°	°	°	°		°	
ASPLEY GUISE,	1881	32·0	36·2	39·7	45·0	55·2	62·0	67·2	60·1	55·8	45·6	45·3	37·3	48·5	75·9	July 15	24·7	Jan. 21
E. E. Dymond,	1882	38·8	39·2	43·3	47·7	55·9	60·2	63·7	61·3	55·6	49·9	40·7	37·4	49·5	67·4	July 3	32·2	Dec. 12
F.R.Met.Soc.	1883	39·0	39·1	36·3	46·1	54·4	61·6	62·5	62·8	57·4	49·9	41·3	38·8	49·1	68·9	June 30	33·2	March 13
433 ft.	1884	40·5	39·9	42·0	46·3	56·2	61·8	65·3	66·1	59·2	48·8	41·3	37·9	50·4	73·0	July 4	33·2	Dec. 31
	1885	34·3	39·8	39·2	46·6	52·7	63·2	66·9	60·6	56·0	45·7	41·0	36·5	48·5	73·4	July 27	32·4	Jan. 25, Dec. 13
NEWTON REIGNY,	1884	..	..	..	..	..	..	59·6	58·7	54·3	46·8	40·3	36·6	..	64·9	Aug. 9, 11	32·0	Dec. 26
T. G. Benn, F.R.Met.Soc.	1885	34·5	37·4	36·3	41·8	45·7	55·7	60·0	55·1	50·3	42·8	38·7	35·6	44·5	68·5	July 26	30·8	Dec. 11
579 ft.																		
6 Ins.																		
ASPLEY GUISE,	1881	32·3	36·4	39·8	44·3	53·6	60·2	65·7	59·2	55·8	45·8	45·5	37·7	48·0	73·2	July 19	24·5	Jan. 22
E. E. Dymond,	1882	39·0	39·4	43·5	47·5	54·6	58·4	62·3	61·1	55·8	50·3	41·4	37·8	49·3	65·0	July 4	33·0	Dec. 14
F.R.Met.Soc.	1883	39·3	39·5	36·9	45·9	53·6	60·6	62·0	62·6	57·6	50·4	41·9	39·3	49·1	67·0	June 30, July 1	33·8	March 13
433 ft.	1884	40·8	40·4	42·5	46·1	55·1	61·1	64·7	65·9	59·4	49·4	42·2	38·5	50·5	70·9	Aug. 9	34·0	Dec. 31
	1885	34·7	40·3	40·0	46·6	52·1	62·3	66·4	60·7	56·2	46·4	41·6	37·3	48·7	71·8	July 27	32·8	Jan. 26
ADDISCOMBE,	1881	34·1	37·7	40·8	45·0	53·8	60·0	65·4	60·6	56·4	45·7	46·9	39·1	48·8	71·0	July 5, 16, 19	31·4	Jan. 17
E. Mawley, F.R.Met.Soc.	1882	39·4	39·8	43·6	47·6	55·0	58·0	61·8	60·3	54·5	51·0	42·7	39·3	49·4	64·9	Aug. 2	33·8	Feb. 5, Dec. 12
201 ft.	1883	40·5	40·2	36·5	45·3	53·4	60·8	61·8	62·3	57·3	50·6	42·8	39·7	49·3	68·5	July 3	33·2	March 13
	1884	41·1	40·8	42·2	45·0	54·3	58·7	63·8	64·4	59·2	49·5	42·3	40·1	50·1	69·8	Aug. 12	34·4	Nov. 25
MARLBOROUGH,	1881	..	..	..	..	..	59·1	64·2	59·3	56·3	45·4	45·9	38·3	..	71·0	July 19	..	....
Rev. T. A. Preston,	1882	39·2	40·0	44·0	47·9	55·1	58·4	62·2	61·6	54·9	49·8	40·8	38·2	49·3	66·0	Aug. 1, 2	32·4	Dec. 11
F.R.Met.Soc.	1883	39·5	39·7	36·5	46·2	53·6	60·9	61·4	61·9	56·9	49·5	41·4	38·4	48·8	67·0	July 3	33·1	March 13
471 ft.	1884	40·9	40·4	41·8	45·2	54·8	60·2	64·1	64·7	59·0	48·0	42·0	39·0	50·0	70·2	Aug. 9	34·1	Dec. 31
	1885	35·6	40·8	39·9	46·5	52·1	62·1	65·0	60·0	55·5	46·3	42·0	37·0	48·6	69·8	July 26	32·8	Dec. 11

TABLE I.—(*Continued.*)

MEAN TEMPERATURE OF THE SOIL FOR EACH MONTH, 1881–85.

Station, Authority, and Height above Sea Level.	Years.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Mean.	Extreme Readings. Highest.	Date.	Lowest.	Date.
6 Ins.		°	°	°	°	°	°	°	°	°	°	°	°	°	°		°	
SOUTHAMPTON, Rev. H. Garrett, F.R.Met.Soc. 136 ft.	1884	42·4	42·7	43·9	47·1	55·3	60·7	64·3	65·9	60·1	50·6	44·6	41·7	51·6	70·7	Aug. 12	36·3	Nov. 30
	1885	37·8	42·3	42·0	48·5	53·1	61·3	65·1	61·5	57·4	48·0	44·0	39·7	50·1	70·4	July 27	34·2	Dec. 11
BABBACOMBE, E. E. Glyde, F.R.Met.Soc. 293 ft.	1881	..	..	..	..	..	..	..	..	58·6	51·1	49·7	42·3	..	..	....	..	....
	1882	43·2	43·9	47·1	50·5	56·4	59·1	62·4	62·8	57·6	53·1	45·6	42·1	52·0	66·4	Aug. 8	35·0	Dec. 11
	1883	43·7	43·0	40·5	49·0	54·6	60·2	62·0	63·0	59·6	53·3	47·1	42·6	51·6	65·5	Aug. 29	36·2	March 11
	1884	44·0	43·9	45·8	48·4	55·0	61·5	63·5	65·0	60·6	52·2	46·7	42·5	52·4	68·3	Aug. 11	38·0	Dec. 27
	1885	39·7	44·0	43·7	48·1	51·9	61·2	64·9	62·7	58·6	49·9	47·0	41·6	51·1	70·0	July 27	35·4	Jan. 14
1 Foot.																		
ALNWICK, J. Lingwood. 213 ft.	1881	36·9	36·6	41·1	45·8	55·1	59·5	62·1	60·1	56·7	48·5	45·2	39·0	48·9	66·0	July 14–16, 19	35·0	Jan. 21, 26, 27
	1882	40·8	41·2	44·3	46·8	54·0	58·1	61·7	62·0	55·8	51·6	41·6	37·2	49·6	66·0	Aug. 11, 12	34·5	Dec. 14, 15
	1883	38·6	39·9	37·6	45·4	51·2	58·9	60·3	60·3	56·9	49·3	41·7	39·8	48·3	65·5	July 2	35·0	March 18
ROUNTON, Sir I. L. Bell, F.R.S., F.R.Met.Soc. 242 ft.	1881	..	..	..	..	..	..	..	..	..	..	45·0	38·6	..	..	....	..	....
	1882	39·2	40·1	42·6	45·7	50·8	56·5	59·8	59·4	54·9	51·1	42·4	37·6	48·3	62·0	Aug. 11	35·0	Dec. 13
	1883	38·4	39·0	37·1	43·6	48·9	55·8	58·3	58·8	56·0	49·3	42·8	39·9	47·3	61·0	July 2–4, 6, 9–11, Aug. 5, 6	35·0	March 18, 19, 25–29
	1884	40·5	39·9	41·2	45·5	50·3	55·3	60·6	60·3	56·3	49·2	44·0	39·0	48·5	63·5	July 6	36·5	Dec. 28, 31
	1885	36·4	39·1	38·9	43·4	47·9	55·7	59·5	57·0	53·4	46·1	42·3	38·1	46·5	64·0	July 27	35·0	Jan. 23–26
LOWESTOFT, S. H. Miller, F.R.Met.Soc. 85 ft.	1881	35·5	37·6	40·9	45·3	52·6	58·1	63·5	59·0	56·1	48·0	46·5	40·0	48·6	68·1	July 20	32·9	Jan. 28
	1882	40·0	40·1	43·7	47·2	54·0	57·6	60·9	61·3	56·5	52·2	44·2	39·5	49·8	64·6	Aug. 13	35·5	Dec. 13
	1883	40·2	40·8	38·0	46·0	52·0	58·7	60·6	60·6	57·9	51·1	44·1	40·4	49·2	66·6	July 4	35·8	March 13
	1884	41·0	41·3	43·1	47·2	53·4	58·3	63·9	64·9	59·4	51·4	44·8	41·1	50·8	68·5	Aug. 12	37·0	Dec. 31
	1885	37·3	40·9	41·4	47·0	50·8	59·0	63·6	60·7	56·4	48·3	43·8	40·2	49·1	66·5	July 27	35·0	Jan. 26

TABLE I.—(*Continued.*)

MEAN TEMPERATURE OF THE SOIL FOR EACH MONTH, 1881–85.

Station, Authority, and Height above Sea Level.	Years.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Mean.	Extreme Readings. Highest.	Date.	Lowest.	Date.
1 Foot.		°	°	°	°	°	°	°	°	°	°	°	°	°	°		°	
HODSOCK,	1882	39·0	40·5	43·5	47·1	53·5	57·2	60·9	60·3	55·8	51·6	42·9	38·5	49·2	63·5	Aug. 10	36·0	Dec. 13
H. Mellish, F.R.Met.Soc.	1883	39·3	39·7	38·6	45·5	51·6	57·4	59·9	59·5	57·4	50·5	42·9	40·5	48·6	62·8	July 9	36·2	Feb. 1
56 ft.	1884	41·1	41·1	42·6	46·5	52·5	57·8	62·0	62·6	58·1	50·6	44·3	39·7	49·9	65·8	Aug. 12	37·0	Dec. 31
	1885	37·0	40·3	40·8	45·5	50·0	57·7	61·1	58·3	54·9	47·6	43·3	38·6	47·9	65·0	July 27	35·2	Jan. 26
STRELLEY,	1881	..	..	..	..	..	..	..	..	..	..	44·8	38·0	..	..	....	..	....
T. L. K. Edge,	1882	39·0	40·0	42·4	45·4	51·7	55·9	59·0	59·0	53·5	49·6	40·9	37·7	47·8	62·5	Aug. 15	35·2	Dec. 12, 13
F.R.Met.Soc.	1883	38·8	39·4	37·1	44·1	50·1	56·5	58·1	57·4	55·3	49·2	42·5	40·1	47·4	61·2	July 3, 4, 9	34·9	March 25
396 ft.	1884	41·1	40·5	41·7	44·6	50·4	55·9	59·7	60·5	56·9	49·2	43·9	39·5	48·7	63·9	Aug. 12	36·8	Dec. 31
	1885	36·7	40·0	40·0	44·0	48·0	55·9	59·1	57·0	53·2	46·2	42·4	39·2	46·8	62·2	July 28	35·2	Jan. 23–26
ASPLEY GUISE,	1881	33·2	36·6	40·8	44·9	53·4	59·8	65·6	59·5	56·2	46·8	45·8	38·4	48·4	73·2	July 20	27·0	Jan. 22
E. E. Dymond,	1882	39·3	39·7	44·0	47·7	54·3	58·0	62·0	61·2	56·3	51·0	42·1	38·1	49·5	64·6	July 4	33·8	Dec. 14
F.R.Met.Soc.	1883	39·8	39·7	37·5	45·9	53·4	60·4	61·8	62·5	58·0	50·9	42·5	39·7	49·3	66·2	July 1	34·8	March 11–14
433 ft.	1884	40·7	40·7	42·6	46·2	54·9	61·0	64·4	66·2	59·1	49·4	42·6	38·7	50·5	70·7	Aug. 9	34·9	Dec. 31
	1885	34·9	40·4	40·4	46·6	51·6	61·8	66·6	61·1	56·3	47·0	41·9	37·7	48·9	71·8	July 27	33·0	Jan. 26
REGENT'S PARK,	1881	34·7	37·5	40·5	44·5	53·9	60·3	66·2	60·9	57·1	47·3	46·8	40·5	49·2	71·2	July 19, 20	31·6	Jan. 26
W. Sowerby,	1882	40·1	40·3	43·8	47·4	54·5	57·7	61·6	61·3	55·4	51·2	43·3	39·4	49·7	64·8	Aug. 15	35·0	Dec. 12–14
F.R.Met.Soc.	1883	41·1	40·2	38·0	44·9	52·8	59·9	61·1	62·0	57·6	50·9	43·1	40·3	49·3	67·0	July 3	35·7	March 11
125 ft.	1884	41·5	41·3	42·2	45·4	52·9	58·7	63·1	64·5	59·3	50·4	43·9	40·5	50·3	68·5	Aug. 12	36·8	Nov. 26
	1885	36·1	40·9	39·2	45·1	50·4	59·6	63·7	60·6	55·8	47·5	42·6	38·7	48·4	67·5	July 28	34·0	Jan. 24–27
ISLEWORTH,	1881	34·3	37·1	41·1	45·4	54·1	60·5	65·7	61·1	58·0	48·2	46·8	39·7	49·3	71·0	July 20	31·2	Jan. 26
Miss E. A. Ormerod,	1882	39·8	40·4	45·0	48·4	55·3	58·0	61·9	61·1	56·3	52·2	43·6	39·4	50·1	64·1	Aug. 1, 2	35·0	Dec. 12, 13
F.R.Met.Soc.	1883	41·1	40·5	38·7	46·6	54·2	60·3	61·7	62·7	58·4	51·7	43·5	40·3	50·0	67·2	July 3	35·9	March 13
68 ft.	1884	41·6	41·8	43·2	46·5	53·7	59·0	63·0	65·0	59·6	50·7	43·4	40·5	50·7	69·1	Aug. 12	35·8	Nov. 26
	1885	35·6	41·2	40·4	46·1	51·4	60·4	63·5	60·1	56·0	47·7	42·7	38·6	48·6	66·9	July 27	33·2	Jan. 26

TABLE I.—(*Continued.*)

MEAN TEMPERATURE OF THE SOIL FOR EACH MONTH, 1881–85.

Station, Authority, and Height above Sea Level.	Years.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Mean.	Extreme Readings. Highest.	Date.	Lowest.	Date.
1 Foot.		°	°	°	°	°	°	°	°	°	°	°	°	°	°		°	
NORWOOD,	1881	35·7	37·9	41·7	45·1	52·8	59·3	64·8	60·8	57·3	47·5	46·4	39·7	49·1	69·5	July 16, 20	33·1	Jan. 26–29
W. Marriott,	1882	39·6	39·9	44·4	48·0	54·5	58·1	61·7	60·8	55·5	51·8	43·7	39·3	49·8	64·0	Aug. 2	35·2	Feb. 5, Dec. 12, 13
F.R.Met.Soc.	1883	41·0	40·4	37·8	45·2	52·5	59·2	61·4	61·6	57·6	51·1	43·2	39·9	49·2	66·1	July 3	35·1	March 13
184 ft.	1884	41·3	41·4	42·7	45·7	53·1	57·5	62·5	63·5	59·2	50·4	43·8	40·7	50·2	67·1	Aug. 13	36·8	Dec. 31
	1885	35·9	41·1	39·9	45·8	50·7	59·5	63·0	60·3	55·9	47·6	42·4	38·7	48·4	66·3	July 24	33·3	Jan. 26
ADDISCOMBE,	1881	35·2	38·1	41·7	45·4	53·5	59·8	65·3	61·4	57·4	47·5	47·3	40·1	49·4	71·0	July 20	33·0	Jan. 18–29
E. Mawley, F.R.Met.Soc.	1882	40·2	40·4	44·7	48·2	54·8	58·1	62·0	60·9	55·6	51·9	44·1	39·9	50·1	64·4	Aug. 1	35·1	Dec. 13
201 ft.	1883	41·3	40·8	37·7	45·7	53·4	60·5	61·9	62·5	58·4	51·7	44·1	40·7	49·9	67·5	July 3	34·8	March 13
	1884	41·7	41·8	43·2	45·8	54·2	58·5	63·8	64·7	60·1	50·8	43·8	40·9	50·8	69·0	Aug. 6	36·2	Nov. 26
MARLBOROUGH,	1881	*34·3*	*37·5*	*41·5*	*45·0*	*53·5*	59·4	64·3	60·2	57·3	47·5	46·6	39·7	*48·9*	69·0	July 19	..	....
Rev. T. A. Preston,	1882	40·1	40·8	45·3	48·9	55·7	59·1	62·9	62·4	56·4	51·4	42·4	38·9	50·4	65·9	Aug. 1	34·5	Dec. 15
F.R.Met.Soc.	1883	40·7	40·5	38·2	47·0	53·8	61·2	61·9	62·5	58·2	51·1	43·1	39·7	49·8	65·7	July 3	35·1	March 12, 13
471 ft.	1884	41·6	41·5	43·1	46·3	55·0	60·4	64·3	65·4	60·2	50·0	44·0	40·2	51·0	69·3	Aug. 9, 12	36·2	Dec. 31
	1885	36·6	41·5	41·4	47·2	52·8	62·2	65·2	61·1	57·0	47·9	43·2	38·6	49·6	68·8	July 28	34·8	Jan. 15–18, 22, 23
HARESTOCK,	1882	41·5	41·8	44·9	47·6	52·0	55·5	58·9	59·5	55·5	52·2	45·3	41·4	49·7	61·4	Aug. 13	37·0	Dec. 12–14
Lt.-Col. H. S. Knight,	1883	43·0	42·2	38·3	44·7	50·7	57·2	58·7	59·6	57·2	51·4	45·8	42·1	49·2	61·8	July 4, Aug. 22	36·0	March 12–14
F.R.Met.Soc.	1884	42·4	42·2	42·3	44·5	51·2	56·3	60·6	61·8	58·2	50·6	45·0	41·6	49·7	65·5	Aug. 12	37·5	Dec. 31
304 ft.	1885	37·4	41·9	40·5	44·3	48·3	56·8	60·7	58·3	55·3	47·9	43·7	40·3	48·0	63·9	July 28	35·5	Jan. 22, 23
STOWELL,	1884	..	..	..	..	..	..	64·5	64·8	61·4	53·0	46·8	42·2	..	68·5	Aug. 23	37·8	Dec. 31
Rev. J. Poole, F.R.Met.Soc.	1885	38·2	42·6	41·9	46·4	51·5	61·5	64·9	61·2	58·1	50·0	45·5	41·0	50·2	68·5	July 27	35·8	Jan. 15, 16
376 ft.																		
ST. LEONARD'S,	1881	35·9	39·7	43·0	47·4	53·8	59·0	64·3	60·7	58·4	50·1	48·8	42·2	50·3	70·1	July 20	32·9	Jan. 26, 27
H. Colborne,	1882	41·8	42·0	46·2	50·2	54·3	57·8	61·8	61·7	58·1	54·6	46·9	42·0	51·5	66·6	Aug. 13	37·7	Dec. 11, 12
116 ft.	1883	43·2	42·8	40·8	..	..	..	..	..	..	..	..	..	..	..	....	..	....

TABLE I.—(*Continued.*)

MEAN TEMPERATURE OF THE SOIL FOR EACH MONTH, 1881-85.

Station, Authority, and Height above Sea Level.	Years.	January.	February.	March.	April.	May.	June.	July.	August.	September	October.	November.	December.	Mean.	Extreme Readings. Highest.	Date.	Lowest.	Date.
1 Foot.		°	°	°	°	°	°	°	°	°	°	°	°	°	°		°	
WORTHING,	1882	41·4	42·0	46·6	50·6	56·6	59·6	63·6	63·2	57·7	53·6	45·4	40·8	51·8	66·5	Aug. 7	36·0	Dec. 12
W. J. Harris,	1883	42·8	42·1	40·1	48·0	55·4	62·0	63·3	63·9	59·8	52·8	45·0	41·7	51·4	67·2	July 3	37·0	March 11
F.R.Met.Soc.	1884	42·7	43·6	45·3	48·2	55·6	60·2	64·8	67·1	61·9	52·8	46·0	42·6	52·6	71·0	Aug. 12	38·4	Dec. 30
21 ft.	1885	38·3	42·7	43·1	48·8	53·6	61·4	63·9	62·3	58·9	50·4	45·1	40·6	50·8	67·2	July 28	36·1	Jan. 15, Dec. 12–14
SOUTHAMPTON,	1881	36·5	39·3	43·6	47·0	53·9	59·5	64·2	61·2	58·5	49·4	48·5	41·8	50·3	68·5	July 20	34·3	Jan. 19–27, 29, 30
Rev. H. Garrett,	1882	41·8	42·3	46·3	50·8	56·0	59·4	62·9	62·4	57·1	52·6	45·4	41·6	51·6	64·9	Aug. 1	36·7	Dec. 13
F.R.Met.Soc.	1883	43·0	42·3	40·2	48·1	54·5	61·0	62·4	62·7	59·0	52·2	45·8	42·2	51·1	66·0	July 4	37·0	March 11
136 ft.	1884	43·4	43·9	45·1	47·9	54·9	59·6	63·2	64·0	60·1	52·0	46·5	43·0	52·0	68·0	Aug. 12	39·3	Dec. 31
	1885	39·1	43·2	43·4	48·9	53·0	60·6	63·8	60·8	57·6	49·6	45·3	41·4	50·6	66·4	July 28	37·0	Jan. 15
NEWTON REIGNY,	1883	..	..	36·1	42·8	47·7	53·7	56·6	55·6	53·3	48·0	41·4	39·4	..	58·2	July 3, 5, 9–11	..	....
T. G. Benn, F.R.Met.Soc.	1884	40·4	39·4	40·2	43·9	49·2	55·2	59·1	59·2	55·5	48·9	43·0	38·5	47·7	63·0	Aug. 12	35·2	Dec. 30, 31
579 ft.	1885	35·7	38·4	38·1	42·2	45·7	53·7	57·9	55·9	51·7	44·9	40·3	37·1	45·1	62·1	July 27	34·0	Dec. 13
CARDIFF,	1881	*36·5*	*40·3*	*43·5*	*47·2*	*54·3*	*58·5*	*62·5*	59·5	56·0	50·1	48·7	43·0	*50·0*	..	....	..	....
W. Adams, F.R.Met.Soc.	1882	43·2	43·8	45·9	48·6	53·1	57·3	60·3	61·1	56·1	51·5	45·1	41·7	50·6	63·3	Aug. 14, 19	37·1	Dec. 14
43 ft.	1883	43·2	42·6	38·8	46·4	51·6	57·9	60·2	61·3	57·7	51·7	46·5	43·0	50·1	62·8	July 8	36·4	March 13
	1884	44·1	43·3	43·7	46·1	52·0	58·6	62·4	62·8	59·2	51·9	45·9	42·2	51·0	66·0	Aug. 12	38·0	Dec. 26
	1885	39·2	43·1	42·7	47·0	51·7	59·9	63·5	60·9	57·5	49·4	45·6	41·7	50·2	68·0	July 28	36·8	Jan. 15
CULLOMPTON,	1881	35·8	39·5	43·2	46·8	54·8	58·6	63·9	59·9	56·5	48·9	48·1	41·2	49·8	69·7	July 19	33·0	Jan. 26
T. Turner, F.R.Met.Soc.	1882	42·0	42·6	46·0	48·8	54·8	57·1	59·8	61·5	56·0	51·6	44·8	41·3	50·5	64·7	Aug. 8, 9	36·3	Dec. 13, 14
202 ft.	1883	43·0	43·0	40·8	47·2	52·6	59·5	60·5	61·6	58·4	51·9	45·6	41·9	50·5	64·0	Aug. 29	38·0	March 11, 12, Dec. 9
	1884	43·4	43·5	45·0	46·9	54·3	60·3	62·5	64·4	60·4	51·8	46·3	42·1	51·7	67·0	Aug. 9, 12	38·2	Dec. 28
	1885	39·3	43·5	42·9	46·6	51·2	59·9	64·4	61·6	57·3	49·1	45·5	40·2	50·1	68·4	July 28	36·0	Dec. 15

TABLE I.—(*Continued.*)

MEAN TEMPERATURE OF THE SOIL FOR EACH MONTH, 1881–85.

Station, Authority, and Height above Sea Level.	Years.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Mean.	Extreme Readings. Highest.	Date.	Lowest.	Date.
1 Foot.		°	°	°	°	°	°	°	°	°	°	°	°	°	°		°	
BABBACOMBE,	1881	38·1	41·7	44·8	48·4	55·5	60·6	64·7	62·1	59·5	52·7	50·4	43·5	51·9	68·7	July 19	34·8	Jan. 25–27
E. E. Glyde,	1882	43·8	44·6	48·0	51·4	56·7	59·6	62·9	63·6	58·8	54·3	47·0	43·0	52·8	66·9	Aug. 8	37·6	Dec. 12
F.R.Met.Soc.	1883	44·7	44·0	42·1	49·7	55·0	60·5	62·2	63·4	60·6	54·4	48·4	43·9	52·4	65·2	Aug. 29, 30	39·1	March 12
293 ft.	1884	44·8	44·8	46·8	49·6	55·5	61·6	63·9	65·2	61·6	54·1	48·5	43·9	53·4	68·0	Aug. 9	39·6	Dec. 30
	1885	40·8	44·7	45·0	49·1	52·8	61·6	65·3	63·8	60·0	51·7	47·9	43·1	52·2	69·5	July 28	37·5	Jan. 15
1½ Foot.																		
MARLBOROUGH,	1881	..	..	..	..	..	58·6	62·4	60·4	57·7	49·4	47·2	41·1	..	68·9	July 17	..	....
Rev. T. A. Preston,	1882	40·8	41·3	45·7	49·1	55·1	58·8	62·6	62·6	57·4	52·6	44·0	39·7	50·8	64·8	Aug. 3	36·3	Dec. 16
F.R.Met.Soc.	1883	41·6	41·0	39·5	46·7	53·1	60·4	61·7	62·3	59·0	52·3	44·8	40·9	50·3	64·1	July 4	37·1	March 13, 14
471 ft.	1884	42·3	42·2	43·8	46·7	54·2	59·6	63·7	65·2	60·7	51·8	45·8	41·5	51·5	68·0	Aug. 12, 13	38·2	Dec. 31
	1885	37·7	41·9	42·2	47·1	52·6	61·2	64·3	61·5	57·8	49·4	44·3	40·1	50·0	67·0	July 28	36·1	Jan. 22–24
2 Feet.																		
ALNWICK,	1881	40·4	39·5	42·1	45·7	53·0	59·5	61·7	60·8	57·9	52·3	48·5	43·8	50·4	64·0	July 16, 19	39·0	Jan. 26, 27, Feb. 6
J. Lingwood.	1882	44·3	44·5	46·8	49·1	54·5	58·5	61·8	62·7	58·4	54·9	47·5	42·6	52·1	65·0	Aug. 12, 13	41·5	Dec. 13–15, 17, 18
213 ft.	1883	43·0	43·2	42·5	47·3	52·5	59·1	61·2	61·0	58·9	53·2	46·8	44·3	51·1	63·0	July 2, 3, 9, 11	40·0	Dec. 16
LOWESTOFT,	1881	36·4	37·5	41·1	45·6	52·8	58·6	63·3	59·9	57·0	49·6	46·8	40·9	49·1	66·9	July 20	33·7	Jan. 26
S. H. Miller, F.R.Met.Soc.	1882	40·3	40·3	43·8	47·2	53·8	57·1	60·7	61·8	57·3	53·1	45·4	39·9	50·1	64·0	Aug. 14, 19, 20	36·0	Dec. 12, 13
85 ft.	1883	40·6	40·9	38·2	45·2	51·2	58·4	60·7	60·8	58·8	52·1	45·5	41·1	49·5	64·6	July 4	36·0	March 17, 25, 26
	1884	41·3	41·4	42·9	47·2	53·2	58·2	64·2	65·8	60·6	52·8	46·0	41·6	51·3	68·5	Aug. 12	38·6	Dec. 31
	1885	37·6	40·9	41·5	46·9	50·8	59·0	63·5	61·1	57·4	49·8	44·6	41·0	49·5	65·6	July 27	35·5	Jan. 26
ASPLEY GUISE,	1881	36·1	37·7	41·7	45·4	52·8	59·1	64·2	60·6	57·3	49·7	47·2	40·9	49·4	69·2	July 5	33·2	Jan. 23, 26–28, 29
E. E. Dymond,	1882	40·8	40·9	45·1	48·3	53·9	57·8	61·8	61·7	57·7	52·7	44·8	40·1	50·5	63·3	Aug. 2	37·2	Dec. 14, 15, 16
F.R.Met.Soc.	1883	41·5	40·9	39·8	46·1	52·7	59·6	61·9	62·5	59·1	52·7	45·4	41·8	50·3	64·2	July 2–4, 9	37·7	March 14
433 ft.	1884	41·9	42·3	43·8	47·0	54·5	60·1	64·0	66·1	60·2	52·4	45·4	40·7	51·5	68·7	Aug. 12	37·6	Dec. 18
	1885	37·0	41·5	42·1	47·1	52·0	61·1	65·7	62·2	57·7	49·5	43·8	40·3	50·0	69·2	July 28	35·7	Jan. 27

TABLE I.—(Continued.)

MEAN TEMPERATURE OF THE SOIL FOR EACH MONTH, 1881-85.

Station, Authority, and Height above Sea Level.	Years.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Mean.	Extreme Readings. Highest.	Date.	Lowest.	Date.
2 Feet.		°	°	°	°	°	°	°	°	°	°	°	°	°	°		°	
ISLEWORTH,	1881	37·6	38·3	41·7	45·3	52·9	59·1	64·3	61·6	58·6	50·9	48·3	42·4	50·1	67·8	July 19	34·9	Jan. 26
Miss E. A Ormerod,	1882	41·5	41·4	45·5	48·6	54·2	57·3	61·1	61·3	57·5	53·6	46·2	41·5	50·8	63·0	Aug. 2	38·6	Feb. 6
F.R.Met.Soc.	1883	42·7	41·6	40·3	46·1	53·0	59·1	61·4	62·4	59·5	53·4	46·5	42·7	50·7	64·1	July 3, Aug. 22	38·6	March 13, 14
68 ft.	1884	43·1	43·0	44·0	47·2	52·9	58·1	62·5	65·0	60·7	53·5	47·2	43·4	51·7	67·0	Aug. 13	40·2	Dec. 31
	1885	38·8	42·3	42·3	46·1	51·2	58·8	62·3	60·9	57·8	50·8	45·6	41·7	49·9	64·5	July 29	37·1	Jan. 27
MARLBOROUGH,	1881	..	..	..	..	..	57·4	61·8	60·3	57·7	51·1	48·1	42·9	..	64·1	July 19, 21	..	....
Rev. T. A. Preston,	1882	41·7	41·8	45·7	48·9	53·9	57·7	61·2	62·0	57·8	53·4	45·8	41·0	50·9	63·1	Aug. 3, 9	38·8	Dec. 17
F.R.Met.Soc. 471 ft.	1883	42·6	41·6	40·7	46·0	51·7	58 6	60·5	61·1	58·9	53·2	46·0	42·4	50·3	61·9	July 9, 10, Aug. 22, 23, 30	39·1	March 14
	1884	43·1	42·9	44·0	46·7	52·6	58·0	62·3	64·0	60·6	53·3	47·7	43·0	51·5	65·7	Aug. 14	40·5	Dec. 31
	1885	39·2	42·3	42·8	46·4	51·6	59·1	62·5	61·2	..	..	..	..	..	64·3	July 29	..	....
HARESTOCK,	1882	42·3	41·8	44·8	47·0	50·4	53·7	57·1	58·3	55·4	52·6	46·8	42·5	49·4	59·2	Aug. 15	39·6	Jan. 27
Lieut.-Col. H. S. Knight,	1883	43·7	42·5	40·0	43·6	48·7	54·6	57·0	57·6	56·5	52·1	47·3	43·5	48·9	58·8	Aug. 29, 31	38·4	March 25, 26
F.R Met.Soc.	1884	43·3	43·2	43·1	44·8	49·6	54·5	59·0	60·4	57·9	52·4	47·6	43·4	49·9	62·0	Aug. 13, 14	40·5	Dec. 31
304 ft.	1885	39·3	42·3	41·7	44·0	48·0	54·8	58·6	57·9	55·7	49·8	45·4	42·5	48·3	60·6	July 29	38·1	Jan. 23–26
MARGATE,	1883	..	..	..	..	..	..	60·5	60·9	59·3	53 9	47·9	..	..	64·2	July 7	..	....
J. Stokes, F.R.Met.Soc.	1884	..	..	..	..	..	..	62·7	64·5	61·0	54·4	48·8	44·8	..	..	....	..	....
83 ft.	1885	40·3	43·2	43·5	46·6	51·3	57·9	61·7	60·8	58·2	51·7	46·8	43·9	50·5	63·5	July 27	38·2	Jan. 26–28
NEWTON REIGNY,	1883	..	..	37·4	42·0	46·5	52·0	55·0	54·4	52·7	48·6	42·5	40·2	..	56·1	July 11	..	....
T. G. Benn, F.R.Met.Soc	1884	40·7	39·6	40·0	43·1	47·4	53·1	57·4	57·9	55·4	50·3	45·2	40·6	47·6	59·8	Aug. 13	37·7	March 5
579 ft.	1885	37·4	39·1	38·9	41·9	45·3	51·8	55·8	55·6	52·2	46·6	42·1	38·9	45·5	58·6	July 28	36·5	Jan. 25, 27

TABLE I.—(*Continued.*)

MEAN TEMPERATURE OF THE SOIL FOR EACH MONTH, 1881-85.

Station, Authority, and Height above Sea Level.	Years.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Mean.	Extreme Readings. Highest.	Date.	Lowest.	Date.
		°	°	°	°	°	°	°	°	°	°	°	°	°	°		°	
3 Feet.																		
NEWTON REIGNY,	1883	..	..	38·7	42·0	46·0	51·2	54·4	54·2	53·1	49·7	44·4	41·8	..	55·0	July 11-14	..	....
T. G. Benn, F.R.Met.Soc.	1884	41·8	40·8	41·0	43·5	46·9	52·2	55·8	56·6	54·8	50·8	46·5	41·9	47·7	58·5	Aug. 16	39·3	Mar. 5, Dec. 31
579 ft.	1885	38·5	39·2	39·1	41·4	44·5	49·9	53·9	54·7	52·1	47·4	43·1	39·7	45·3	56·3	Aug. 1, 2	37·8	Jan. 26, 27
3·2 Feet.																		
(Observations at Noon.)																		
GREENWICH (Roy. Obs.),	1881	40·3	40·4	42·6	45·6	51·5	57·9	63·3	61·9	58·6	53·0	49·7	45·2	50·8	65·9	July 21	37·5	Jan. 29
The Astronomer Royal.	1882	43·4	42·7	45·8	48·5	53·1	57·0	60·7	61·8	58·4	54·8	48·6	43·6	51·5	62·7	Aug. 15	41·0	Feb. 6
155 ft.	1883	44·4	43·0	41·8	45·7	51·2	58·1	61·1	61·7	60·2	55·0	49·3	44·9	51·4	63·0	Aug. 30	40·6	March 17
	1884	44·3	44·3	45·0	47·5	52·4	57·2	62·6	64·7	62·0	55·9	50·1	45·3	52·6	66·3	Aug. 14	42·7	March 4
	188	41·0	43·2	43·2	46·5	50·9	58·6	62·8	62·7	59·2	52·6	47·4	44·0	51·0	65·2	July 30, Aug. 1	39·3	Jan. 27
4 Feet.																		
LOWESTOFT,	1881	41·1	40·1	42·0	45·1	49·5	54·5	59·2	58·2	56·1	51·7	48·0	44·3	49·2	61·2	July 21	38·8	Feb. 1
S. H. Miller, F.R.Met.Soc.	1882	42·5	42·1	44·3	46·8	50·8	54·7	57·5	59·1	56·5	53·7	47·8	42·9	49·9	60·0	Aug. 14, 15, 17-22	41·4	Feb. 6, 7
85 ft.	1883	42·9	42·2	41·0	44·4	48·9	54·8	57·8	57·8	57·4	53·1	48·1	43·9	49·4	59·1	Aug. 27, 29	39·1	March 28
	1884	43·5	43·3	43·7	46·6	50·4	54·8	59·6	61·4	59·0	54·3	49·0	44·5	50·8	62·4	Aug. 19, 25	42·0	March 2-6
	1885	41·1	42·3	42·9	45·6	49·3	54·7	59·2	59·0	56·7	50·9	46·5	43·8	49·3	63·2	Aug. 1	40·0	Jan. 26-29
ASPLEY GUISE,	1881	40·2	39·3	41·7	44·3	49·5	55·2	59·4	58·9	57·0	52·1	48·5	44·2	49·2	61·6	July 23	37·5	Feb. 1-3
E. E. Dymond,	1882	42·4	42·0	44·8	47·3	51·3	55·0	58·5	59·9	57·5	54·1	47·9	42·8	50·3	60·4	Aug. 15-17	40·9	Feb. 7, 8, 10
F.R.Met.Soc.	1883	43·2	42·0	41·6	44·7	49·7	56·0	59·0	59·9	58·5	54·0	48·4	44·3	50·1	60·5	Aug. 30, 31	40·4	March 25, 26
433 ft.	1884	43·7	43·5	[illegible]	[illegible]	[illegible]	[illegible]	60·5	62·6	59·7	54·5	49·0	44·1	51·3	63·8	Aug. 19	42·0	Dec. 31
	1885	40·2	42·0	42·7	45·5	[illegible]	56·7	61·1	60·6	57·4	51·8	46·6	43·3	49·8	63·0	July 30, 31	39·0	Jan. 26-29

TABLE I.—(*Continued.*)

MEAN TEMPERATURE OF THE SOIL FOR EACH MONTH, 1881–85.

Station, Authority, and Height above Sea Level.	Years.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Mean.	Extreme Readings. Highest.	Date.	Lowest.	Date.
4 Feet.		°	°	°	°	°	°	°	°	°	°	°	°	°	°		°	
REGENT'S PARK,	1881	40·1	38·6	40·3	42·7	48·4	55·2	60·4	60·5	57·7	52·1	48·2	44·7	49·1	62·7	July 22	35·5	Jan. 29
W. Sowerby, F.R.Met.Soc.	1882	42·5	41·4	43·8	46·0	50·2	54·5	58·0	59·7	57·0	53·3	47·5	42·8	49·7	61·0	July 5	40·5	Feb. 9–11
125 ft.	1883	43·3	41·5	41·1	43·1	48·3	55·1	58·5	59·2	58·6	53·9	48·3	44·2	49·6	60·5	Aug. 29–31, Sept. 1–3	40·0	March 20–25, 28, 29, 31
	1884	43·4	43·0	43·0	45·4	48·8	54·6	59·6	61·6	59·9	55·2	49·6	44·3	50·7	63·0	Aug. 25	41·8	March 6–8, 11
	1885	40·7	41·5	41·5	43·1	48·0	54·5	58·9	60·5	57·7	51·7	46·4	43·4	49·0	61·5	Aug. 3–5	39·5	Jan. 25–31
HARESTOCK,	1883	45·1	43·6	42·6	43·4	46·9	51·9	54·8	55·6	56·0	53·4	49·9	46·1	49·1	56·8	Sept. 3	41·2	March 30, 31, April 1
Lt.-Col. H. S. Knight,	1884	45·0	44·7	44·3	45·5	47·4	51·6	55·6	57·5	57·0	54·2	50·6	46·6	50·0	58·2	Aug. 21, 22, 27	43·7	March 12
F.R.Met.Soc. 304 ft.	1885	43·1	43·3	43·4	44·1	47·1	51·2	55·0	56·3	55·4	52·1	48·3	45·6	48·7	56·7	Aug. 1–7, 9	41·7	Jan. 28
NEWTON REIGNY,	1883	..	..	39·4	41·7	45·3	50·2	53·3	53·6	52·8	50·1	45·2	42·4	..	54·0	Aug. 4, 6, 30, 31	..	....
T. G. Benn, F.R.Met.Soc.	1884	42·2	41·2	41·1	43·3	45·9	50·9	54·0	54·7	54·0	50·9	47·2	42·9	47·4	55·4	Aug. 17	40·0	March 5–8
579 ft.	1885	39·7	39·7	39·5	41·0	43·7	48·1	51·9	53·4	51·5	47·8	44·0	40·7	45·1	54·1	Aug. 3, 4	39·0	Jan. 25–30
CARDIFF,	1881	..	..	..	..	..	..	..	56·8	55·5	53·2	50·5	48·1	..	..	....	..	....
W. Adams,	1882	46·2	45·3	46·4	47·5	49·8	53·1	55·9	57·6	56·5	54·2	50·2	46·5	50·8	58·2	Aug. 22, 23, 25, 26	45·0	Feb. 10–15
F.R.Met.Soc.	1883	46·3	45·2	43·9	44·7	47·8	52·2	55·2	56·7	56·7	54·1	50·9	47·6	50·1	57·5	Aug. 31, Sept. 1	42·1	March 26
43 ft.	1884	46·7	45·9	45·4	46·4	48·9	52·8	56·6	58·2	57·7	54·9	52·1	48·4	51·2	58·7	Aug. 20	45·0	March 5–10, 12–16
	1885	44·9	45·4	45·5	46·6	49·8	54·2	57·7	59·3	57·8	53·9	50·4	47·5	51·1	61·8	Aug. 12	44·0	Jan. 25–28

TABLE II.

MEAN EARTH TEMPERATURE, 1881–1885.

Station.	Jan.	Feb.	Mar.	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Year.
3 Ins.	°	°	°	°	°	°	°	°	°	°	°	°	°
Aspley Guise ..	36·9	38·8	40·1	46·3	54·9	61·8	65·1	62·2	56·8	48·0	41·9	37·6	49·2
6 Ins.													
Aspley Guise ..	37·2	39·2	40·5	46·1	53·8	60·5	64·2	61·9	57·0	48·5	42·5	38·1	49·1
Marlborough ..	..	..	..	..	..	60·1	63·4	61·5	56·5	47·8	42·4	38·2	..
Babbacombe ..	..	..	..	..	..	..	..	..	59·0	51·9	47·2	42·2	..
1 Ft.													
Lowestoft	38·8	40·1	41·4	46·5	52·6	58·3	62·5	61·3	57·3	50·2	44·7	40·2	49·5
Aspley Guise ..	37·6	39·4	41·1	46·3	53·5	60·2	64·1	62·1	57·2	49·0	43·0	38·5	49·3
Regent's Park ..	38·7	40·0	40·7	45·4	52·9	59·2	63·1	61·9	57·0	49·5	43·9	39·9	49·4
Isleworth	38·5	40·2	41·7	46·6	53·7	59·6	63·2	62·0	57·7	50·1	44·0	39·7	49·7
Norwood	38·7	40·1	41·3	46·0	52·7	58·7	62·7	61·4	57·1	49·7	43·9	39·7	49·3
Marlborough....	*38·7*	*40·4*	*41·9*	*46·9*	*54·2*	60·5	63·7	62·3	57·8	49·6	43·9	39·4	49·9
Southampton ..	40·8	42·2	43·7	48·5	54·5	60·0	63·3	62·2	58·5	51·2	46·3	42·0	51·1
Cardiff	*41·2*	*42·6*	*42·9*	*47·1*	*52·5*	*58·4*	*61·8*	61·1	57·3	50·9	46·4	42·3	50·4
Cullompton ...	40·7	42·4	43·6	47·3	53·5	59·1	62·2	61·8	57·7	50·7	46·1	41·3	50·5
Babbacombe	42·4	44·0	45·3	49·6	55·1	60·8	63·8	63·6	60·1	53·4	48·4	43·5	52·5
1½ Ft.													
Marlborough....	..	..	..	..	..	59·7	62·9	62·4	58·5	51·1	45·2	40·7	..
2 Ft.													
Aspley Guise ..	39·5	40·7	42·5	46·8	53·2	59·5	63·5	62·6	58·4	51·4	45·3	40·8	50·3
Isleworth	40·7	41·3	42·8	46·7	52·8	58·5	62·3	62·2	58·8	52·4	46·8	42·3	50·6
Lowestoft	39·2	40·2	41·5	46·4	52·4	58·3	62·5	61·9	58·2	51·5	45·7	40·9	49·9
3·2 Ft.													
Greenwich	42·7	42·7	43·7	46·8	51·8	57·8	62·1	62·6	59·7	54·3	49·0	44·6	51·5
4 Ft.													
Aspley Guise ..	41·9	41·8	43·0	45·7	50·3	55·8	59·7	60·4	58·0	53·3	48·1	43·7	50·1
Regent's Park ..	42·0	41·2	41·9	44·0	48·7	54·9	59·1	60·3	58·2	53·2	48·0	43·9	49·6
Cardiff	..	..	..	..	..	..	..	57·7	56·8	54·1	50·8	47·6	..
Lowestoft	42·2	42·0	42·8	45·7	49·8	54·7	58·7	59·1	57·1	52·7	47·9	43·8	49·7

TABLE III.

MEAN AIR TEMPERATURE, 1881–1885.

Station.	Jan.	Feb.	Mar.	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Year.
	°	°	°	°	°	°	°	°	°	°	°	°	
Lowestoft	38·3	40·9	41·2	45·1	50·6	55·8	60·6	59·7	56·7	49·3	44·2	39·6	[illegible]
Aspley Guise ..	37·3	40·6	41·0	45·6	51·6	57·1	61·2	59·7	55·6	47·2	42·6	38·0	[illegible]
Regent's Park ..	38·8	42·0	42·6	47·5	53·5	58·9	63·0	61·6	57·3	48·7	44·5	40·0	[illegible]
Isleworth	38·2	42·0	42·4	47·4	53·1	58·8	62·4	61·1	57·0	48·6	44·0	39·5	[illegible]
Norwood	38·7	42·1	42·4	47·0	53·1	58·6	62·6	61·3	56·8	48·6	44·2	40·0	[illegible]
Greenwich......	38·4	41·9	42·4	47·4	53·8	59·3	63·7	62·2	57·2	48·6	44·2	39·7	[illegible]
Marlborough....	37·8	41·0	41·0	45·4	51·3	56·7	60·5	59·1	55·3	47·1	42·7	38·6	[illegible]
Southampton ..	38·7	42·2	42·3	46·9	52·1	57·6	60·8	60·2	56·4	48·6	44·3	40·0	[illegible]
Cardiff	39·9	42·7	42·9	47·4	52·9	58·0	61·2	60·2	56·4	48·8	45·0	40·6	[illegible]
Cullompton	39·9	42·6	42·4	46·3	51·7	56·8	60·1	59·1	55·7	48·6	45·0	40·6	[illegible]
Babbacombe	41·6	43·8	43·6	46·6	51·9	57·0	60·3	60·2	56·6	50·2	46·8	42·6	[illegible]

warm up the surface of the soil, and there is also a longer interval between the time of the minimum air temperature and the 9 a.m. observation.

At the London stations the temperature of the air and soil agree very closely throughout the year, especially in the summer months. This appears to be due to the nature of the soil, which is clay.

At Aspley Guise there is a much greater range in the temperature of the soil than at any other station. At this place the soil is very light, being of a sandy nature.

Mr. Buchan has shown "that light soils are subject to a greater degree of frost near the surface than strong clay soils, but that frosts do not penetrate so far down into light soils as into strong clay soils, the explanation being that light loose soils are worse conductors of heat than strong clayey compact soils. Hence the heat which is radiated to the ground from the sun during the day, being less quickly conveyed downwards into light sandy soils by conduction, will be left to accumulate, so to speak, nearer the surface than in the case of strong heavy soils." (*Journ. Scot. Met. Soc.* Vol. II. p. 277.)

Possibly the clay, being a damp soil, may be cooled by the evaporation of some of its moisture on the surface.

The results show that the warmest year was 1884, and the coldest 1885, and in some cases 1881. The mean temperature at 1 foot in 1884 was about 2° warmer than in 1885.

The highest temperature observed at 1 foot was 73°·2 at Aspley Guise in July 1881. The lowest temperatures observed were 27°·0 at Aspley Guise and 31°·2 at Isleworth, both in January 1881. These are the only stations where frost penetrated the soil to the depth of 1 foot.

It is to be hoped that at the end of the next lustrum there will be a much larger number of complete returns available for instituting a more detailed comparison between the temperature of the air and the temperature of the soil.

NOTE ON THE AFTER-GLOWS OF 1883-1884. By ARTHUR W. CLAYDEN, M.A., F.R.Met.Soc., F.G.S.

[Read May 19th, 1886.]

THE appearance of Professor Riccò's paper[1] on the after-glows and attendant phenomena, coinciding with the publication of Dr. A. Riggenbach's pamphlet[2] on the same subject, has, to a certain extent, reopened the discussion upon their cause.

If the attention be confined to the optical effects, which are too familiar to need description, there seem to be two theories of their origin, first, that those effects were produced by the dust ejected from Krakatoa during the

[1] *Quar. Jour. Roy. Met. Soc.* Vol. XII. p. 49.
[2] See Review in *Nature*, March 25th, 1886.

great eruption in Sunda Straits in August 1883; secondly, that they were the consequence of an abnormal humidity of the air. I wish to make a third suggestion, which to some extent reconciles the two, namely, that the cause is to be found in the water vapour erupted from the volcano; and that the dust and other ejecta played but a secondary part in the production of the phenomena.

That there was a real sequence of events clearly and unmistakeably traceable back to the eruption was shown, almost beyond question, so long ago as December 8th, 1883, in Mr. Norman Lockyer's article in the *Times*.

It is well known that in an explosive eruption such as the one referred to the chief substance ejected is steam. Mr. Lockyer, in the *Times* article, himself says "millions of tons of matter, and perhaps millions of cubic miles of vapour, have been hurled into the upper air." He explains at length how water vapour could have produced the phenomena, and then goes on to argue that dust might very conceivably be able to do the same.

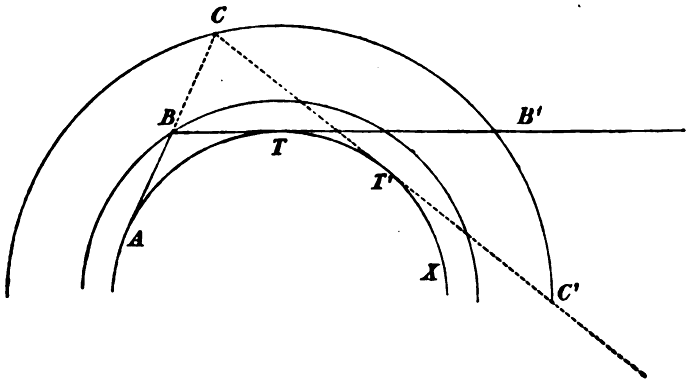
The dust theory seems to rest upon the following points:—1. The evident connection between the eruption and the phenomena. 2. During that eruption dust was thrown out in enormous quantities. 3. The phenomena could have been produced by volcanic dust. 4. Small quantities of such dust were observed to fall in various places very far removed from the seat of the eruption. 5. The evidence of the spectroscope.

The first three points apply still more forcibly to the far larger quantity of vapour. The fourth is no argument to the contrary, because small quantities of dust must inevitably be swept along with the vapour. The fifth point is of much greater importance; for what was this evidence? Lockyer thus sums up Professor Piazzi Smyth's report:—"The rainband, a band produced, as I hold, by a special form of aqueous vapour in our air widely different from that which absorbs the blue, is now at a minimum, while the dry air band is at a tremendous maximum. He adds as a corollary—'The light, therefore, from that red haze has passed through an extra length of extra dry air.'"

This seems to effectually dispose of the theory which refers the phenomena to exceptional humidity of the air, but it is no obstacle whatever to the theory I would suggest. Just as it has been shown that the great dust cloud might spread itself out into a thin layer encircling the earth, so also would the much vaster cloud of vapour which must have accompanied the dust.

Now it has been calculated that the height of the reflecting medium must have been about 40 miles. Let A T T' X represent a part of the earth's circumference, with a thin stratum of ordinary cirrus cloud at B at a height of 10 miles, and another thin film of cloud at the altogether abnormal height of 40 miles. Then if we neglect the effect of refraction, B^1 B A will represent the course taken by the last ray reflected to A from B, while C^1 C A is that taken by the last ray reflected from C. Now calculation shows that if the radius of the earth is taken at 4,000 miles, B^1 B A is equal to about 1,130 miles, while C^1 C A is no less than 1,700 miles; the additional distance being twice C B, and being wholly confined to the upper and drier regions of the

atmosphere. It is thus clear that so far as the rainband and dry air band are concerned, the difference in level of C and B is sufficient explanation.



This does not exhaust the spectroscopic evidence. Other absorption bands make their appearance, but these may have been caused either by the extra distance passed in very rare air, or quite possibly by some of the other ejecta, such as dust, sulphur dioxide, hydric chloride, and so forth, some of which would most probably travel with the vapour and exert their influence upon the sun's light at C¹. The fact that the rainband was at a minimum during some of the most brilliant displays may surely be explained by saying that it was when the air as a whole, or rather in its lower and denser portions, was driest it was also clearest, and so allowed both a brighter light to fall on the reflecting substance, and the reflected rays to be seen best.

It seems then that the spectroscopic evidence does not in any way prove that the reflecting stratum was not chiefly cloud, necessarily composed of minute particles of ice.

That dust could remain suspended for a great length of time of course none can doubt, but water vapour could most certainly remain longer. Even the cloud particles condensed from it would not weigh more than one fifth as much as equally small particles of dust, while the uncondensed vapour, weighing only about five eighths as much as the dry air beneath, would float until diffusion had mixed it with the air. Indeed, it does not seem so very wonderful to suppose that of some "millions of cubic miles of vapour" projected through the atmosphere into a region where the pressure is a mere fraction of an inch, enough should have escaped immediate condensation on the spot to expand into a layer surrounding the earth and floating aloft for months. The low pressure is a point of some importance because it will facilitate the expansion of the vapour, and will account for the extreme fineness of the precipitated particles,[1] but will make it much more difficult to understand dust floating for so long.

Finally, if the phenomena were due to dust only, how is it there are so few

[1] See *Nature*.

records of the fall of volcanic dust? Surely it should have been noticed, at least in those parts of the world where the effects were strongest, wherever there were observers to observe. If, however, they were mainly caused by water vapour, the condensed particles would slowly descend and evaporate in the lower regions of the atmosphere.

It seems to me that if we suppose the great dust cloud to have spread out along the upper surface of our air till it formed a layer encircling the globe, while the water vapour, which must have enfolded each dust particle in its own much vaster volume, was all condensed in a short time, we have then a phenomenon more wonderful and inexplicable than all the other marvels attending that great catastrophe.

DISCUSSION.

Mr. ARCHIBALD said that Mr. Clayden had only looked at one side of the case. All his calculations were based upon the assumption that the secondary glow was the reflection of the direct rays from the sun, whereas it was certain from an examination of the information received that the secondary glow was a reflection from the primary. This really disposed of the whole of Mr. Clayden's arguments, as the height of the dust was thus reduced from 40 to 13 miles. He then referred to spectroscopic observations made in Madras and Edinburgh, which confirmed the dust theory, and remarked that the experience of astronomers served to show that the effects were most certainly due to something besides water vapour. With regard to the possibility of dust remaining in suspension for a long time at any great height, a formula of Prof. Stokes showed that the dust could be as easily suspended at a great height as at the earth's surface.

Mr. STANLEY said the laws of vapour were well known. At certain altitudes the tendency of vapour was to condense and descend in drops. Mineral particles could not condense. In a paper read before the Society,[1] he had considered the possibility of the after-glows being due to fine dust particles remaining floating in the upper air from Krakatoa. He had since thought of two conditions which would strengthen his hypothesis:—1. That the heat of the volcanic eruption would form an upward current or climbing through the air, which would carry fine dust particles up to a distance much beyond that due to the force of their original progression. 2. That a particle projected from the earth would carry with it a minus velocity equal to the difference of circumferential velocity at the original place, and at its final place of extreme projection, and this would form a factor of horizontal projection where gravity would have small influence, and very rarified air less resistance than near the earth.

Mr. RAMSAY inquired at what temperature it was possible for all aqueous vapour to be withdrawn from the air, and instanced such temperatures as those registered in the Arctic regions.

MR. CLAYDEN, in a note to the Secretary, said that he did not see how the reduction of the height of the reflecting material from 40 to 13 miles disposed of his arguments. If the light of the secondary glow was a double reflection it must have passed through a thickness of about 645 miles of air more than the light from a primary one. The argument, therefore, remained unaltered, though resting on a somewhat different basis. He had not attempted to deny that the effects may have been partly due to dust, nor that great quantities of dust may have remained suspended for some considerable time. What he maintained was that wherever dust went, there also must water vapour have gone in much greater quantity; and therefore there is a *primâ facie* reason for attributing the effects chiefly to it. The advocates of the dust theory do not seem to have yet adduced any argument to the contrary; nor to have attempted any answer to the questions suggested in the last paragraph of his note.

1 *Quarterly Journal*, Vol. X. p. 187.

THE FLOODS OF MAY 1886. By WILLIAM MARRIOTT, F.R.Met.Soc., Assistant Secretary, and FREDERIC GASTER, F.R.Met.Soc.

[Read June 16th, 1886.]

THE month of May 1886 will long be remembered for the heavy rains that occurred between the 11th and 13th, and the disastrous floods they produced over the greater part of the West and Midland Counties of England; at Worcester the flood was higher than any that have occurred there since 1770.

Rainfall.—On Tuesday and Wednesday, the 11th and 12th, heavy rain fell over the East of Ireland, there being more than 3 inches during these two days at several places in the Counties of Down, Dublin, Meath and Wexford, and also in the Isle of Man. The greatest falls reported were:—3·52 ins. at Kilkeel; 3·44 ins. at Fassaroe (Bray); 3·34 ins. at Seaforde; 3·17 ins. at Navan; 3·01 ins. at Newtonwards; and 3·28 ins. at Cronkbourne, Douglas, Isle of Man. Several streams overflowed their banks, and traffic on the County Down Railway had to be suspended.

Over the other parts of the United Kingdom the rainfall on the 11th was under 1 inch.

Rain, however, commenced falling about noon on Tuesday, the 11th, over the Midland Counties of England, and continued, but with increasing intensity, till Friday morning; the duration at most places being about sixty and in some places nearly seventy hours.

The heaviest fall occurred in Shropshire, where during the three days more than 6 inches fell at several stations, and at Burwarton as much as 7·09 ins. was recorded. At Church Stretton, 4·12 ins. is reported to have fallen on the 13th.

The accompanying Table gives the rainfall for all stations at which the total during the three days, May 11th to 13th, exceeded 2 inches.

The distribution of the rainfall is shown in fig. 1 (p. 272). From this it is seen that five inches or more of rain fell all over the South of Shropshire, and also near Sheffield; four inches fell over Shropshire, Hereford, Monmouth, Montgomery, and parts of the adjoining counties; and also on the borders of Derbyshire and the West Riding of Yorkshire. Three inches fell over the Western Counties, Nottingham, Derby, the East of Wales, the Isle of Man, and parts of Counties Down and Dublin. Two inches fell over the whole of the Western Counties, portions of the Midlands, Lincolnshire, Yorkshire, Lancashire, nearly the whole of Wales, and the Eastern parts of Ireland. One inch and upwards fell over nearly the whole of England, and the greater part of Ireland. In Scotland very little rain fell, the greatest amount during the whole period being 0·29 in. at Nairn.

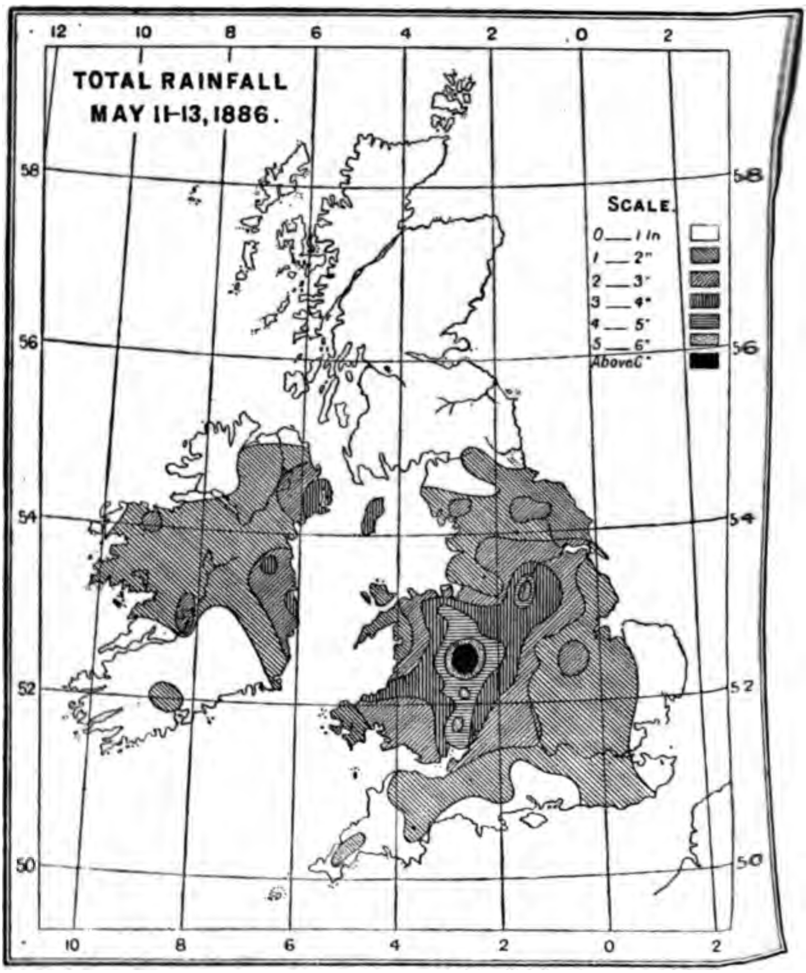
STATIONS AT WHICH THE RAINFALL ON MAY 11TH TO 13TH, 1886, EXCEEDED 2 INCHES.

Station.	County.	Rainfall.			
		11th.	12th.	13th.	Total.
ENGLAND, N.E.		In.	In.	In.	In.
Greenhow, Ingleby	York	·01	·51	2·17	2·69
Mickley, Ripon	,,	·03	1·59	·59	2·21
Houghton	,,	·10	·20	1·86	2·16
Brigg	Lincoln	·07	·58	1·44	2·09
Bucknall, Horncastle	,,	·13	·35	1·60	2·08
MIDLAND COUNTIES.					
Wakefield	York	·13	1·75	1·10	2·98
Stanley, Wakefield	,,	·07	1·40	1·00	2·47
Redmires, Sheffield	,,	·37	2·44	2·44	5·25
Rivelin, ,,	,,	·26	2·10	2·25	4·61
Crookes, ,,	,,	·22	1·92	1·98	4·12
Chatsworth	Derby	·30	1·81	2·19	4·30
Holloway, Wirksworth	,,	·43	2·48	1·90	4·81
Belper	,,	·17	1·81	1·26	3·24
Oakamoor	Stafford	·17	1·10	1·56	2·83
Cheadle	,,	·27	1·20	1·65	3·12
Hoar Cross, Abbot's Bromley	,,	·32	1·61	1·90	3·83
Hengoed, Oswestry	Shropshire	1·58	1·92	1·60	5·10
Buntingsdale, Market Drayton	,,	·39	·75	2·35	3·49
Willey Park, Much Wenlock	,,	·50	2·04	2·21	4·75
Woolstaston	,,	·58	2·42	3·32	6·32
Preen, Church Stretton	,,	·44	2·22	3·25	5·91
Larden Hall, Much Wenlock	,,	·35	2·75	3·30	6·40
Burwarton	,,	·60	3·10	3·39	7·09
Church Stretton	,,	..	..	4·12	..
Middleton-in-Chirbury	,,	·49	1·39	2·34	4·22
More, Bishop's Castle	,,	·47	1·67	3·59	5·73
Bishop's Castle	,,	·57	1·75	3·30	5·62
Stokesay	,,	·54	2·20	2·57	5·31
Cleobury Mortimer	,,	·33	2·08	2·32	4·73
Rhos-y-perfedd, Garthbibio	Montgomery	·41	1·97	·85	3·23
Llanwnog, Carno	,,	·55	·98	2·70	4·23
Tybrith ,,	,,	·82	1·10	2·23	4·15
Buttington, Welshpool	,,	·90	1·30	2·65	4·85
Churchstoke	,,	·68	1·37	2·78	4·83
Downton, New Radnor	Radnor	·51	1·69	2·81	5·01
Penybont, ,, ,,	,,	·35	·70	2·11	3·16
Ednol, ,, ,,	,,	·51	1·52	2·53	4·56
Gwern-y-Arglwydd, New Radnor	,,	·50	·90	3·10	4·50
Nantgwillt, Rhayader	,,	·79	1·47	1·33	3·59
Brynarlais, Llandrindod	,,	..	·68	1·56	..
Llanstephan	,,	·77	1·11	1·82	3·70
Lynhales, Kington	Hereford	·63	1·93	2·40	4·96
Hope-under-Dinmore	,,	·25	1·90	2·03	4·18
Portway, Burghill	,,	·30	2·16	1·79	4·25
Burghill	,,	·29	2·17	1·90	4·36
Hereford	,,	·27	1·65	3·50	5·42
Ross	,,	·28	1·70	1·40	3·38
Bryngwyn, Much Dewchurch	,,	·30	2·64	1·86	4·80
Acock's Green, Birmingham	Worcester	..	1·70	1·75	..
Orleton, Tenbury	,,	·28	2·23	2·12	4·63
Lincombe Lock, Stourport	,,	·29	1·67	1·55	3·51
Ombersley, Droitwich	,,	·17	1·52	1·40	3·09
Holt Lock ,,	,,	·22	1·63	1·81	3·66
Worcester	,,	·22	1·55	1·72	3·49
Bevere Lock, Worcester	,,	·22	1·63	1·72	3·57
Diglis ,, ,,	,,	·25	1·85	1·65	3·75
Madresfield, Malvern	,,	·31	1·98	1·76	4·05
Beckford, Tewkesbury	Gloucester	·44	1·35	1·19	2·98
Upper Lode, ,,	,,	·30	1·31	1·10	2·[illegible]
Cheltenham	,,	·25	1·09	·94	2·28
Maismore Lock, Gloucester	,,	·34	1·64	1·01	2·99
Llanthony ,, ,,	,,	·28	1·52	·90	2·70

IONS AT WHICH THE RAINFALL ON MAY 11TH TO 13TH, 1886, EXCEEDED 2 INCHES.

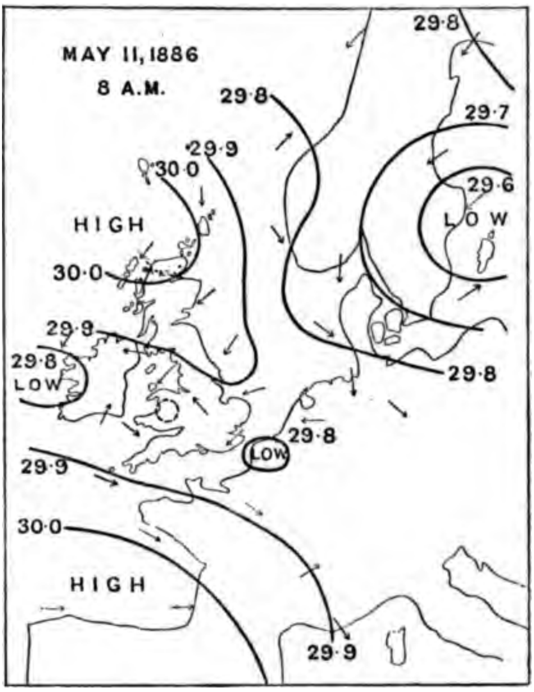
Station.	County.	Rainfall.			
		11th.	12th.	13th.	Total.
AND COUNTIES—*continued.*		In.	In.	In.	In.
d, Stroud	Gloucester	.32	1.72	.78	2.82
ester	"	.45	.95	.71	2.11
ampton, Bristol	"	.35	1.11	.82	2.28
ı, Bristol	"	.28	1.07	.96	2.31
tone	Warwick	.20	1.26	1.50	2.96
try	"	.25	1.30	.96	2.51
on, Coventry	"	.27	1.40	1.05	2.72
orth	"	.30	1.59	1.20	3.09
ide, Stratford-on-Avon	"	.30	1.20	.94	2.44
borough	Leicester	.17	.81	1.39	2.37
ton, Leicester	"	.14	1.13	1.36	2.63
ate, "	"	.18	.84	1.20	2.22
am, "	"	.15	.83	1.12	2.10
rand, "	"	.19	.88	1.29	2.36
Brigg, "	"	.23	.93	1.09	2.25
liffe, "	"	.21	1.08	1.29	2.58
Hall Square, Leicester	"	.18	.83	1.01	2.02
Orton	"	.30	1.00	1.45	2.75
ı, Stamford	Rutland	.34	.78	1.51	2.63
e	Northampton	.36	.87	1.02	2.25
l	Oxford	.36	1.30	.51	2.17
ENGLAND, N.W.					
ourn	Cumberland	.75	.85	.84	2.44
Rochdale	Lancashire	.44	1.64	.27	2.35
ale, Frodsham	Cheshire	.66	.96	1.60	3.22
l, "	"	.84	1.24	1.36	3.44
r	"	.73	1.50	1.31	3.54
yn Hall, Rosset	Denbigh	.91	1.65	1.36	3.92
idno	Carnarvon	1.10	1.05	.47	2.63
Corwen	Merioneth	.10	.84	1.77	2.71
ENGLAND, S.W.					
ron, Aberayron	Cardigan	.35	.62	1.51	2.48
Malgwyn, Llechryd	Pembroke	.63	.82	1.73	3.18
Park, Clarbeston	"	1.16	.16	1.06	2.38
overy	Carmarthen	.37	.68	1.47	2.52
rthen	"	.70	.35	1.30	2.35
wessin, Builth	Brecknock	.73	1.61	2.44	4.78
rtyd Wells, Builth	"	.11	1.00	2.19	3.30
ı-y-fed Park, Hay	"	.43	1.06	2.31	3.80
f	Glamorgan	.66	1.22	1.01	2.89
ardiff	"	.65	.82	1.53	3.00
th, Cardiff	"	.38	1.22	1.09	2.69
idge	"	.43	.62	1.51	2.56
field, Abergavenny	Monmouth	.88	2.77	1.44	5.09
echfa	"	.85	2.25	1.40	4.50
n-super-Mare	Somerset	.27	.97	.93	2.17
ISLE OF MAN.					
bourne, Douglas	Isle of Man	.69	2.59	.04	3.32
ia Road, "	"	.64	2.27	.05	2.96
IRELAND.					
Barnsley, Belfast	Antrim	.57	1.67	.03	2.27
wnards	Down	.89	2.12	.10	3.11
hadee	"	.63	1.40	.14	2.17
gstown	"	.72	2.05	.01	2.78
de	"	.86	2.48	.40	3.74
l	"	1.02	2.50	.23	3.75
h, Navan	Meath	1.09	2.08	..	3.17
h, Balbriggan	Dublin	1.26	1.43	.21	2.90
ı	"	1.15	1.27	.45	2.87
ill	"	..	..	..	3.25
roe, Bray	"	1.47	1.97	.50	3.94
own House, Gorey	Wexford	1.02	.45	1.11	2.58
coe, Crossmolina	Mayo	1.24	.74	.09	2.07
castle, Killaloe	Tipperary	.98	.67	.44	2.09

FIG. 1.



Pressure. The distribution of atmospheric pressure and the wind which prevailed during this period were of a most complex character. On the morning of the 11th, two high-pressure systems were prevalent—one over the Iberian Peninsula and the Bay of Biscay, the other off the north of Scotland. The zone of relatively low pressure which separated these two systems proved to be (as is generally the case with such zones) a region of very disturbed weather; only in this case the disturbances developed were more numerous and of greater intensity than usual. Thus at the time mentioned three distinct minima were observed (see fig. 2)—one over the north-east of France, another off the west of Ireland, and a third (very badly defined) over Wales. The first had advanced to the position it then occupied from Spain, and was filling up quickly, after producing thundery unsettled

FIG. 2.



ıer over France. The second was advancing south-eastwards from ıtlantic, and later in the day underwent considerable modification, partly ıiting with the third system over Wales, and partly by the development of ı minimum at the mouth of St. George's Channel (see fig. 3, p. 274). What ːred subsequently (*i.e.* during the night) it is impossible to say. Either ʳhole system collapsed and a new one advanced to the south of Ireland the Atlantic, or else the three minima merged and formed one well ːed system, the position of which is shown on fig. 4, (p. 274.) One thing, ›ver, is certain, viz. that the bulk of the rainfall during these twenty-four s (and it was heavy) occurred with the Easterly wind on the northern north-eastern sides of the disturbance, not with the South-westerly ., as might naturally have been expected. Thus the maximum falls were rded over the east of Ireland, the Irish Sea, and Wales, the region in h they were recorded being marked by the shaded area in fig. 4. The of demarcation between this region and that of the smaller falls, which rred owing to the generally disturbed character of the weather, is very ːly defined.

ʳe come next to the period of twenty-four hours, from 8 a.m. on the 12th a.m. on the 13th. In this time the depression which lay off the south reland, and which has just been referred to, moved eastwards up the tol Channel and almost entirely filled up: a new minimum, however, was ːloped near Cherbourg and advanced north-eastwards to the Sussex coast,

FIG. 3.

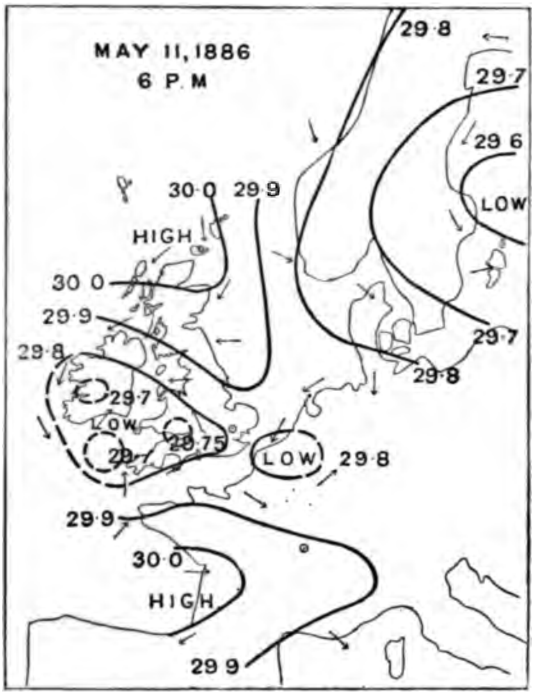

MAY 11, 1886
6 P. M
29·8
29·7
29·6
LOW
30·0
29·9
HIGH
30 0
29·9
29·8
29·7
LOW
29·75
LOW
29·8
29·7
29·8
29·9
30·0
HIGH
29 9

FIG. 4.

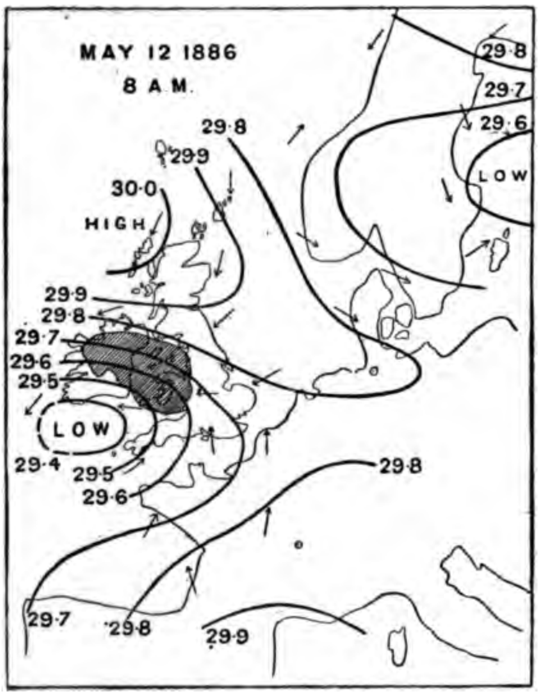

MAY 12 1886
8 A.M.
29·8
29·7
29·6
LOW
29·8
29·9
30·0
HIGH
29·9
29·8
29·7
29·6
29·5
LOW
29·4
29·5
29·6
29·8
29·7
29·8
29·9

FIG. 5.

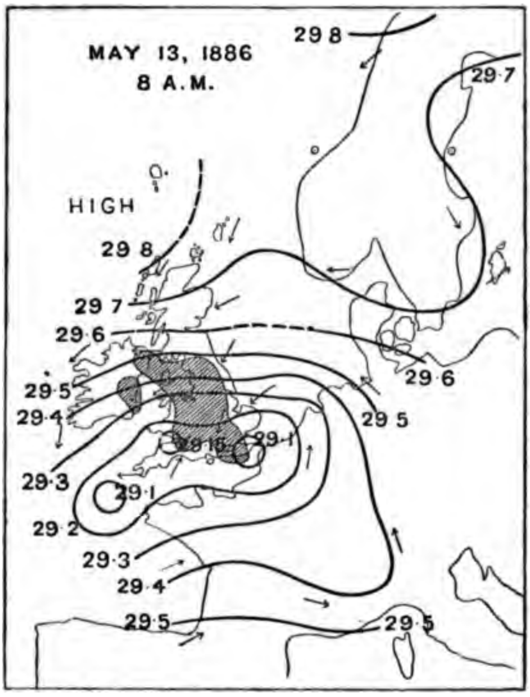
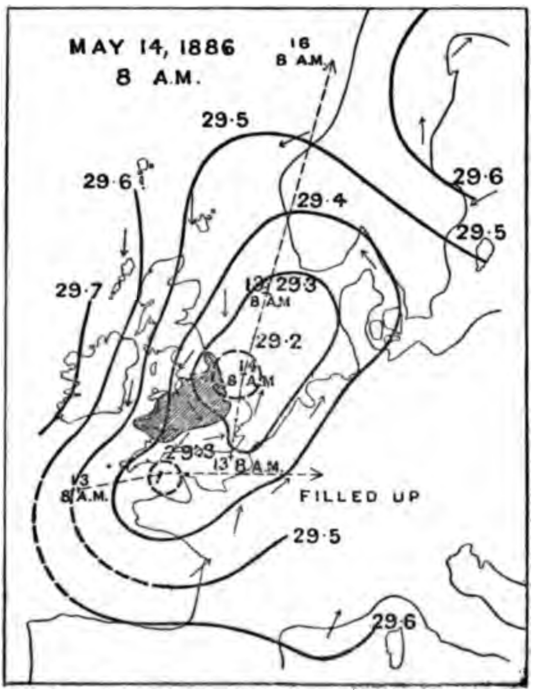

MAY 13, 1886
8 A.M.
HIGH
29 8
29·7
29 8
29 7
29·6
29·5
29·4
29·3
29·2
29·1
29·15
29·1
29·6
29·5
29·3
29·4
29·5
29·5

FIG. 6


MAY 14, 1886
8 A.M.
16
8 A.M.
29·5
29·6
29·4
29·6
29·5
29·7
13 8 A.M
29·3
29·2
14 8 A.M
29·3
13 8 A.M.
13 8 A.M.
FILLED UP
29·5
29·6

while a third appeared at the mouth of the English Channel. The position occupied by these three minima at 8 a.m. on the 18th is shown in fig. 5 (p. 275). The two high-pressure areas remained unchanged. Thus throughout this period of twenty-four hours cyclonic Easterly winds were continuously prevalent except on our south-western coasts, and it was with these winds that the enormous falls of the 12th-13th took place. In fig. 5 we see the distribution of pressure at 8 a.m. on the 13th, and the shaded area shows the region in which the maximum fall had occurred. Here we see that England was the chief sufferer, and a more detailed map would show that the heaviest falls of all occurred with the Easterly winds on the northern sides of the various minima referred to. This is very clearly shown by comparing the falls over different parts of our southern counties; for while over Cornwall, Devon, and the south of Dorsetshire, the rainfall (which accompanied South-west and South winds) varied from almost *nil* to only a few tenths of an inch, the fall over Sussex, some parts of Kent, and Middlesex, where the East winds of the eastern minimum were experienced, amounted in all cases to an inch or more.

An important change now took place. The eastern minimum continued its movement northwards across Sussex, Kent, Essex, Suffolk, and Norfolk, and then over the North Sea to the west of Norway (see fig. 6, p. 275); while the western one moved eastwards up the Channel, and the shallow one over the Bristol Channel. The wind consequently became Northerly almost all over the country, and temperature fell fast. A great deal more rain fell over Wales and the Midland and North-eastern Counties of England, and was afterwards accompanied by wet snow, some of which fell even over our own Southern Counties. During the 14th, however, both systems passed slowly away, the high-pressure area in the north broke into two parts, one of which moved southwards over the Atlantic, the torrential rains ceased, and the weather improved greatly.

There are two remarkable points about this period of bad weather. One is, the very disturbed conditions which were produced in the zone which separated the two co-existent anticyclones over our area, one lying to the northward of the other. This has not hitherto been sufficiently dwelt on by writers on depressions, though the idea is somewhat hinted at in the suggestion that hurricanes are often produced in the Indian Ocean by the prevalence of Easterly winds on the polar side of a current from the westward. The second and most striking point is, that when these conditions are established the rainfall is greatest in those regions where the surface wind is Easterly. Numerous instances of this may be quoted, but will not be referred to here, as Mr. Gaster proposes to bring the matter before the Society on a future occasion. The feature stamps such systems as being of a type distinct from those which usually prevail over North-west Europe.

In the present case there is one other feature which is worth notice, viz. that the rain which fell in the North-east of Ireland during the 11th, appears to have fallen in the *rear* rather than the *front* of the depression to which it belonged. This is less clear at present than could be wished, but will be considered on another occasion.

Floods and Damage.—The heavy rains of the 11th to 18th caused very serious floods. The greatest was in the valley of the Teme, especially at its junction with the Severn below Worcester. These floods caused great loss of life and damage to property; bridges were washed away, railway traffic suspended, and thousands of workmen thrown idle. In several places the Waterworks and the Gasworks were flooded, and the town water and gas supplies were consequently cut off.

It has been impossible to collect particulars of all the damage done in various parts of the country, but the following notes from several of the principal places affected will give a fair idea of the extent both of the floods, and of the amount of damage and distress caused thereby.

WORCESTER.—The waters of the Severn and Teme continued to rise until 1 a.m. on Saturday, when they reached a point higher than any flood since 1770, and 2 inches higher than the flood of 1795, so that the inundation was greater than any similar visitation for 116 years. No one now living remembers anything like such a deluge as that which occurred at Worcester, either for the unexpectedness with which it came about or the height to which the water rose. There is no record of such a flood in summer, all previous great floods having been in the winter. That of 1770, which was only 2½ inches higher than the present one, occurred in November. That of 1795 was in February, when the river below the bridge was blocked with ice; and there is a tradition that this held back the water above the bridge and made the flood some 12 inches higher above than it was below the bridge. The great flood of 1852 happened in November, and was 5 inches below the point now recorded.

About midday on Friday the 14th, the railway bridge over the Teme between Bransford and Henwick gave way in consequence of the flooding of the river. The centre pier collapsed, and although the railway metals remained they sank down with the structure, and the line became impassable.

The present flood will be remembered not only for its severity but for its prolonged duration. The hope which many people cherished that the waters, when they once had reached their height, would subside almost as rapidly as they had risen, was disappointed. The subsidence indeed from the first was remarkably slow, and during the whole of Saturday could be reckoned only by inches. Fortunately by Saturday evening something like adequate efforts were made to cope with the distress of those who were suffering most keenly from the effects of the prolonged inundation.

At the Corporation Waterworks great consternation was created on Friday afternoon by the flood waters getting into the grounds, and then rapidly rushing into the boiler houses. Some steam fire engines were procured, and were kept constantly at work to prevent the flood reaching the boilers. The water, however, reached the fires and put them out, so that the engines could not pump to the reservoir for the supply of the city. All through Friday night the place was watched with the greatest anxiety by the engineers and others, and every effort was made to keep down the water in the boiler houses. On Saturday the grounds and works were completely flooded, the whole of the filtering and other tanks being under water. The result was that, instead of there being a constant supply of water to the city, there was only a little to be obtained for half-an-hour in the morning and for half-an-hour in the afternoon. On Saturday night, the floods having receded to the extent of a foot, the boilers became accessible, and the pumping engines were at work all night.

GLOUCESTER.—Gloucester has once more been visited by one of those periodically recurring floods caused by the Severn in its upper reaches, and the overflowing of its banks into the long stretch of level meadow land adjoining the river, and the lowlying portion of the city bordering on the river and canal.

Already on Friday evening water was spreading over the Ham meadows, and during the night it rose rapidly, and on Saturday morning the flood was fully upon us. At nine o'clock, the height of the water at the lock-gate at the entrance to the canal was 18 ft. 10 ins. The appearance from the bridge at Llanthony or

from Westgate bridge was that of a vast lake, far as the eye could stretch. The trees, the tops of the hedges, and notice boards stuck here and there, dotted the expanse of waters.

The rapidity with which the water rose was illustrated on the road to Hatherley, which was perfectly clear at 10 o'clock in the morning, but by 12 o'clock was covered to a depth of nearly two feet. During Saturday night the water continued to rise, and at 9 on Sunday morning it registered 22 ft. 1 in. at the lock. During the day it rose 2 inches more, and the maximum was reached on Sunday evening, when it measured 22 ft. 3 ins., or within 4 ins. of the great flood of 1852.

The district around Hempstead suffered severely. The engine house of the reservoir, which supplies the inhabitants with drinking water, was flooded so as to compel pumping operations to be suspended, and in consequence the water had to be turned off early each evening.

The flood began to subside on Monday, and during the night fell a foot. On Tuesday and Wednesday the water gradually sank and left all the streets and courts, leaving only the meadows covered; by Thursday the visitation, as far as the streets and dwelling-houses are concerned, may be said to have gone.

SHEFFIELD.—The river Don continued to rise throughout Thursday night, and reached its maximum height between 5 and 6 o'clock on Friday morning, when it is said to have been higher than for many years past. Fortunately the rain ceased an hour or two afterwards, and from then, throughout the day, the river gradually fell until the evening, when, so far as Sheffield was concerned, all danger had passed; but lower down the river, between Tinsley and Rotherham, matters were still of a very serious nature. All the mills and factories on the banks of the Don, in which water power is used, were stopped, and many firms who do not use water as a motor power were put to great inconvenience by the flooding of portions of their works, and it may be considered within the mark that between 700 and 800 men were thrown idle by the flooding.

At Denaby the flood is said to be the most serious for twenty years: the water rushed down the Denaby Pit, necessitating the stoppage of the work, and the men had to reach their homes by means of rafts.

ROTHERHAM.—Never within the memory of living man has there been a flood at Rotherham so great as the one which is now carrying devastation and ruin along the banks of the rivers Don and Rother. Events of eleven, and even of thirty-seven years ago, are alluded to, but the floods of those periods are stated not to have reached anything like the magnitude of the present inundation. The whole town has been thrown into a chaotic state. Public establishments, manufactories, and tradesmen's shops, have had to suspend operations because it is impossible to reach them. Business is at a standstill, and at least from 3,000 to 4,000 workmen are out of employment. Houses are inundated, roads rendered impassable, and on one of the railways—the Manchester, Sheffield, and Lincolnshire—traffic has been stopped since Thursday night.

From early morning the water continued to rise rapidly; between three and six o'clock it went up most quickly, a circumstance remarkable when the large area inundated is taken into account. Opinions vary, but the height of the river was undoubtedly from 12 to 15 feet above the ordinary level, and remained so during the greater portion of the morning. On all sides there was water; the meadows, the highway, the walls, the hedges, and the outbuildings had disappeared, either partially or totally, and the rivers Rother and Don passed along like a surging sea. The road had been impassable for foot passengers and vehicular traffic from Thursday night. The Bessemer Steel Works of Messrs. Steel, Tozer, & Co., had had tons of sewage and mud lifted out of the bed of the river and deposited among the machinery, and large quantities of debris and timber had floated down and lodged there.

At the Waterworks it was ascertained that something had gone wrong. At first it was thought that the water had backed up from the overflow into the retaining tank, but this was found not to be the case. The drains run on the side of the retaining tank, and owing to the pressure of storm water the joints had given way, and the water had escaped and entered the tank through the suction pipe.

Many of the engine-drivers employed by the M. S. and L. Company had to work hard and to make good use of their wits to get safely to Mexborough (or, as one

driver jocularly remarked, to "port") with their trains. In many instances it was found impossible for them to get through the flood, and they were forced to remain, some at one place and some at another, until the waters had subsided. At Wath large numbers of people assembled on the bridge over the railway for the purpose of watching the huge engines make their way through the flood—no light task, when it is estimated that the water was three feet in depth at this point. The head lights of one engine were extinguished, and the fires of another were, in the words of the driver, "doubted out."

CHURCH STRETTON.—A flood, far greater in its effects than has been known for nearly half a century, occurred at Church Stretton last week. Rain commenced to fall at an early hour on Tuesday morning, and continued without intermission until midday on Friday. The quantity of rainfall in that time was almost incredible. Some idea of the total fall may be gleaned from the fact that during Thursday 4·12 ins. of rain fell, and this at an altitude of 624 ft. above sea level. This enormous rainfall, over the eighty square miles of the Longmynd, soon began to make itself felt in the increased volumes of the many brooks and torrents running down its sides.

KIDDERMINSTER.—On Friday and Saturday nights there was no gas supply in some parts of the town, owing to the water having entered the mains through the meters in the flooded cellars.

The fire engines were at work on Saturday pumping water from the flooded mills and dwelling houses. The total damage is estimated at about £10,000.

BEWDLEY.—A portion of the Teme bridge, walls and houses were carried away.

LEIGH.—The railway bridge on the Worcester and Bromyard line subsided.

BRANSFORD.—The railway bridge on the Worcester and Hereford line subsided.

LUDLOW.—Two railway bridges between Ludlow and Craven Arms, on the Hereford and Shrewsbury line, were washed away.

NOTTINGHAM.—The overflow of the Trent caused the inundation of the whole of the southern part of the town, comprising 3,000 houses. The Midland line between Nottingham and Trent was submerged for nearly six miles.

Rivers flooded.—The following is a list of the principal rivers and their tributaries which were flooded and overflowed their banks :—

SEVERN, Avon, Belu, Camlad, Ceunant, Clywedog, Dolfor, Lleden, Stour, Vyrnwy.

TEME, Clun, Corve, Ledwyche, Onny, Rea.

WYE, Arrow, Dore, Frome, Lugg, Mon, Monnow, Twddi.

TRENT, Amber, Anker, Derwent, Ecclesbourn, Idle, Ryton, Sour, Tame, Wye.

DEE, Alyn.

Also, the Aire, Calder, Derwent (Yorks), Rye, Cod, Wiske, Clwyd, Goyt, Nen, and Witham.

The times at which the flood waters reached their highest point were as follows :—

13th.—Night, Church Stretton.

14th.—2 a.m., Welshpool ; 4 a.m., Tenbury ; 6 a.m., Churchstoke ; morning, Ludlow, Worksop ; noon, Shrewsbury, Leominster, Matlock ; 2 p.m., Belper ; 4.30 p.m., Rotherham ; 7 p.m., Kidderminster ; night, Evesham.

15th.—1 a.m., Worcester ; 2 a.m., Diglis Lock ; 8 a.m., Burton-on-Trent ; evening, Nottingham ; midnight, Tewkesbury.

16th.—11 p.m., Gloucester.

Flood Levels.—The following are the heights of the flood at various places above the average summer level :—

SHREWSBURY.—15th, noon. Extreme height of flood at Welsh Bridge, 16 ft,

WORCESTER.—

			ft.	ins.	
11th,		Water in the Severn		4	above average summer level.
12th,		„ „ „		5	„ „ „ „
13th,	7 a.m.	„ „ „	2	6	„ „ „ „
„	4 p.m.	„ „ „	10	0	„ „ „ „
„	8 p.m.	„ „ „	11	9	„ „ „ „
14th,	7.15 a.m.	„ „ „	14	3	„ „ „ „
„	10.40 a.m.	„ „ „	15	8	„ „ „ „
„	5.30 p.m.	„ „ „	17	0 (nearly)	„ „ „
15th,	1 a.m.	„ „ „	17	10	„ „ „ „

DIGLIS LOCK, NEAR WORCESTER.—15th. The water of the Severn reached its highest point at 2 a.m., being then about 25 feet above low summer level. This was only a few inches below the flood of 1770.

ROSS.—15th. The flood in the Wye was 14 feet 3 inches.

GLOUCESTER.—

			ft.	ins.
14th,	9 a.m.	Depth of water at Lock gates on the Quay	18	2
15th,	9 a.m.	„ „ „ „ „	18	10
„	9 p.m.	„ „ „ „ „	21	6
„	11 p.m.	„ „ „ „ „	21	7
16th,	3.45 a.m.	„ „ „ „ „	22	0
„	7.30 a.m.	„ „ „ „ „	22	1
„	9 a.m.	„ „ „ „ „	22	1¼
„	4 p.m.	„ „ „ „ „	22	1¾
„	8.30 p.m.	„ „ „ „ „	22	2
„	8.40 p.m.	the tide caused it to rise half an inch	22	2½
„	9 p.m.	no appreciable difference was manifested	22	2½
„	11 p.m.	another quarter of an inch was registered	22	2¾
17th,	6 a.m.	it had fallen 3½ inches	21	11¼
18th,	9 a.m.		21	0
19th,	9 a.m.		19	9
20th,	9 a.m.		18	7

ROTHERHAM.—14th, 7.30 p.m. The flood was 8 feet 5 inches at the junction at Bow Criag.

BELPER.—14th, 2 p.m. The flood in the Derwent was 4 feet 3½ inches.

NOTTINGHAM.—15th, evening. The rise of the water in the Trent has been 12½ feet.

N.E. YORKSHIRE.—15th, p.m. The Derwent has risen to nearly 11 feet above summer level.

HEIGHTS OF FORMER GREAT FLOODS.

WORCESTER.

			ft.
1672	December 23rd.	Flood above summer level ...	16·63
1770	November 18th.	„ „ ...	17·56
1795	February 11th.	„ „ ...	16·91
1852	February 8th.	„ „ ...	14·43

				ft.
2	November 15th.	Flood above summer level	...	15·93
1	February 6th.	" "	...	14·93
6	May 15th.	" "	...	17·10

Ross.

				ft.	ins.
5	February 11th.	Flood above summer level	...	18	1
9	January 27th.	" "	...	17	8
1	November 24th-25th.	" "	...	17	8
1	February 10th.	" "	...	17	8
2	November 16th.	" "	...	17	8
6	May 15th.	" "	...	14	8

Gloucester.

5	February.	Depth of Water at Lock Gates	...	22	8½
2	September 15th.	" "	...	22	7
7	January 5th.	" "	...	21	8
6	May 16th.	" "	...	22	8

Nottingham.

				ft.
5		Flood above summer level (estimated)		14·60
2	November.	" "	...	18·42
7		" "	...	11·48
1	March.	" "	...	11·18
9	December.	" "	...	12·50
5	July 23rd.	" "	...	12·0
	October 22nd.	" "	...	18·75
6	May 15th.	" "	...	12·70

Belper.

				ft.	ins.
4	October 12th.	Water above "flood" level[1]	...	4	8
7	December 21st.	" "	...	4	1
9	July 31st.	" "	...	4	2½
0	November 16th.	" "	...	3	10½
5	December 28th.	" "	...	4	5
9	October 8th.	" "	...	4	5
2	February 5th.	" "	...	4	0
5	October 21st.	" "	...	4	2
0	January 1st.	" "	...	4	0
1	February 9th.	" "	...	4	8
6	May 14th.	" "	...	4	8½

Previous Floods at Worcester.
(From *Berrow's Worcester Journal.*)

-Extraordinary flood. The extreme rise of the Severn was noticed wall by the side of the river near the College Green, and a plate still (1770) in the wall recording the event.

record has been kept in one of the wheel houses in Messrs. Strutt's Mills. its are in feet and inches above "flood" level, the point to which the back- the "tail-races" must rise to necessitate stopping the water-wheels.

1770. November.—The excessive rains occasioned an extraordinary overflow of the rivers Severn, Avon, Teme, &c., and a most alarming flood ensued, being the highest and most extensive ever known in these parts.

In order that it might be known how much the present flood exceeded that of 1672, the Dean engaged a proper person to watch the rise of the water against the wall, and to observe its utmost reach, which, it seems, was about two o'clock last Sunday morning, when it had rose ten inches above the high water mark of the year 1672.

1795. February.—The late severe frost has been succeeded by a calamity almost as dreadful in its effects. The river Severn has overflowed its banks and covered an extent of country for a great number of miles with water. The water continued rising the whole of last Thursday, and its utmost height was only about 7 inches lower than the memorable flood in 1770; but at Bridgnorth it was 6 inches, and at Coalbrooke-dale 16 inches, higher than at that period.

The flood rose in Gloucester to within 6 inches of that in 1770. Shrewsbury was almost surrounded by water.

In most places the waters have risen higher than was ever remembered by the oldest inhabitants; upwards of 50 bridges have been totally destroyed, and a great number of others much damaged. The Fen counties exhibit sheets of water for miles in extent, and the damage done in those parts is estimated at £500,000.

1852. November.—The incessant rains of Wednesday and Thursday tended to augment the swollen waters to an extent truly alarming. The flood overspread the race ground, Pitchcroft, and on Sunday was stated to have attained the astonishing height of from 13 ft. to 15 ft. The water on Sunday rose on the North Parade to within 11 ins. or 12 ins. of the height attained by one of the highest floods ever known on the Severn, which occurred in 1795. On Monday afternoon the flood-mark of 1795 on the North Parade was attained within 4½ inches.

DISCUSSION.

Mr. Marriott exhibited a number of photographs showing the extent of the floods on the Severn at Worcester and some of the damage caused thereby, and also some photographs and sketches of the floods at Rotherham.

Mr. Southall said that he had had considerable experience in the investigation of floods in the Severn and Wye, and the determination of flood levels, and he hoped that one result of this paper would be to cause more careful observations to be made in future. It was extremely difficult to get good information respecting floods in the past owing to the obliteration of flood-marks. The height of the flood at Worcester in 1672 was carefully marked on the Cathedral steps by the Dean; but the flood-marks at Gloucester were extremely unsatisfactory. In great floods the fluctuations in the water level made it difficult to ascertain the extreme height accurately, and great care was necessary that the height of the flood and not of the 'wash' was obtained. With respect to the floods of May, he could find no record of such a flood in the Severn during the summer. It was not a mountain flood, and seemed to be entirely due to heavy local rainfall. At Shrewsbury the flood was 4 feet lower than some of recent times.

Mr. Hawksley said that maximum floods were those for which engineers had to make provision in the construction of drainage systems and waterworks, and he gave the formula used for ascertaining the amount of water which will flow off a given area, and for which the engineer in constructing drainage works would have to make adequate provision for carrying off in order to prevent flooding. The winter floods were usually due to the sudden melting of snow, whilst summer floods were generally the result of heavy rainfall during thunder-storms, and were almost of the same character and intensity in all parts of the country. These summer floods usually extended over but small areas, but winter floods were generally of very large extent. The greatest flood he remembered occurred in August 1846, when 4 ins. of rain fell in London in 3 hours and 20 minutes. He then went on to say that engineers were greatly indebted to meteorologists for the information collected by them concerning floods and rainfall, for without such knowledge it would not be possible for engineers to carry on their work efficiently. In conclusion he strongly urged students of

meteorology to investigate the causes of the various phenomena connected with their science and so increase the practical utility of their work.

Mr. H. C. Fox said that such a downfall of rain occurring in May was very remarkable. At Greenwich, the fall during the three days, May 11th to 13th, amounted to 1·57 in., and was preceded by ten days without rain. The total for the month (4·23 ins.) was exactly double the average, and there were only three wetter Mays at Greenwich back to 1815. He drew attention to his paper on "The Sequence of Mean Temperature and Rainfall in the Climate of London," read before the British Association, in which he had shown that there was a marked tendency for a very wet May to be followed by a cold June.

Mr. J. Smyth, Junr., said that, at Banbridge in Ireland, the rainfall recorded in May was the largest during the past twenty-six years.

Mr. Strachan drew attention to the fact that the front of a depression was the part where most rain fell, condensation taking place first and the mechanical results immediately following. But in the case of the depression in which this great rainfall took place the conditions were said to be reversed, the rain falling in the rear of the low pressure area.

Mr. Symons thought that the differences between the relative height of the Severn at Shrewsbury and Worcester were due to the fact that the river Teme, in the watershed of which the greatest rainfall took place, flowed into the Severn a little below Worcester, while at the head waters of the Severn only a comparatively small rainfall was measured. It was fortunate that a good organisation of rainfall stations and river gauging throughout the Severn basin had lately been inaugurated by Mr. Willis Bund, and was in working order when this rain came, as authentic and valuable records would be obtained from them. He noticed that the greatest rainfall occurred at the conflict of the two currents of air as shown on the charts, and he thought that it was the mingling of these warm and cold currents which gave rise to the excessive rainfall.

Mr. Gaster, in reply, said that the important fact in regard to this depression was that maximum rain fell with an Easterly and not with a Westerly wind, and in one case it had apparently occurred in the rear instead of in front of an advancing depression. Instances in which the maximum rainfall occurred with the Easterly wind on the northern side of advancing depression, though somewhat rare, were far from being unique, and were worthy of more consideration than they had received. The fact is becoming more and more strongly recognised that anticyclones are the real "weather-makers," and that on their relative position to one another the occurrence of different spells of weather mainly depended.

On Atmospheric Pressure and its Effect on the Tidal Wave. By Captain W. Nelson Greenwood, F.R.Met.Soc. (Abstract.)

[Read June 16th, 1886.]

The Author in this paper has endeavoured to show by careful and continued observation the connection which exists between the pressure of the atmosphere and the height of the tides, confining his observations for the most part to the neighbourhood of Glasson Dock, Lancaster, on the River Lune. When it is considered, he says, that a rise or fall of half an inch in the mercury of the barometer is equal to the addition or removal of 31·26 pounds per square foot of area, an idea may be formed of the enormous, though imperceptible, influence that such addition or removal will have upon the extended surface of the sea. Water, in itself inelastic, incapable of compression to any perceptible amount, is still subject in a marked degree to the fluctuations in atmospheric pressure. Knowing, as we do, that no great displacement of the atmosphere can occur at a given point without a corresponding

area of high or low pressure being found in some near locality, we may naturally argue that the waters of the ocean, being inelastic, will follow such atmospheric displacement, by giving way with increased pressure in one place, accumulating where the decrease of pressure is in operation, and again returning to their original position when the disturbing pressure is removed. On the progressing tide wave this influence, the author says, is most marked. As the wave advances up the St. George's Channel and Irish Sea from the Atlantic Ocean it is subject to, and influenced by, the atmospheric pressure obtaining in the locality through which it travels, to a degree which is scarcely appreciated. The wave, it appears, takes about six hours to travel from the entrance of the Channel to the shores of Morecambe Bay, where it joins its sister tide which is coming in from the North Channel, the wave having traversed a distance of about 240 geographical miles. The normal difference in atmospheric pressure, taking the mean of four years' observations, is ·048 inch, the mercury standing higher by that amount at the entrance of the Channel than in the vicinity of Morecambe Bay. In other words, the mean barometrical reading in Morecambe Bay is 29·900 ins., and that at the entrance of the Channel 29·948 ins., being equivalent to ·007 inch of a mean gradient per 40 geographical miles.

In considering the effect of this gradient on the tide wave, the author lays down the following four propositions:—

1. A rise in the barometer over the whole distance would depress the tide wave locally.
2. A rise locally, or a fall distantly, would depress the wave locally.
3. A fall generally over the whole distance would raise the tide wave locally.
4. A fall locally, or a rise distantly, would raise the wave locally.

The author goes on to show by copious examples, tables and diagrams, how, with these propositions in view, predictions of the tide heights may be made with great certainty when the atmospheric conditions are known and carefully studied. He gives in a table the number of inches to be added to, or subtracted from, the usual predicted tidal heights for every condition of atmospheric pressure from 28·7 ins. to 30·6 ins. The table, of course, only refers to one locality, viz. Glasson Dock, but similar tables could be prepared by the same rules for other places. Another table shows the results of this method of prediction, which indicates that the height of the tide wave can be estimated within a very few inches when the barometric correction has been applied.

The conclusions to which the author has arrived are,—that the motion of the waters of the tidal wave can be shown to be intimately connected with the fluctuations of the atmosphere as indicated by the barometer; and that the wave obeys these fluctuations closely, irrespective of the interruption it may receive from local surroundings, such as the narrowing of channels or estuaries up which it may have to pass; and that the discrepancies which may occur between predictions made in the mode now suggested and the observations are distinctly traceable to variations of pressure over a defined area in the vicinity, and not to the force or direction of the wind, as now

generally supposed. Further, that the position and path of such storm-centres as reach our coasts, as also the number that may be included in a certain area, have to be taken into consideration, if a true idea is to be formed of the influence of storm depression on the tidal wave in its passage up the Irish and North Seas and English Channel.

The author thinks that with the aid of the information contained in the Daily Weather Reports of the Meteorological Office, there are no difficulties which cannot be readily overcome, so that a table of corrections may be formed that will rectify the tidal predictions at any port with almost unerring certainty.

METEOROLOGICAL RESULTS AT LEVUKA AND SUVA 1875-1885, WITH NOTES ON THE CLIMATE OF FIJI. By J. D. W. VAUGHAN, F.R.Met.Soc., Government Storekeeper.

[Read June 16th, 1886.]

THE Fiji Islands lie between 15° and 22° S lat. and 175° E and 177° W long., they are therefore wholly within the tropics. The Islands number some 255, many of these are not inhabited, some being mere sandbanks, with here and there a few trees growing on them, while the largest Island, Viti Levu, contains some 4,250 square miles; the second largest, Vanua Levu, 2,600 square miles.

The larger Islands are mostly mountainous, rising in many places to an altitude of from 2,000 to 6,000 feet above the sea level, and are clothed to the summit with forest, rich grasses, and undergrowth.

The rivers are numerous, and during the wet seasons subject to floods from the hills which skirt the foot of the mountains, whilst fringing the numerous bays which indent the coasts are to be found rich alluvial plains, stretching for many miles into the interior. On these rich plains and river banks are to be seen growing the various products of the tropics, carefully tended by hundreds of Fijians, Polynesians, and Coolie labourers. From the foregoing it will be seen that the climate of the whole of the Fiji Islands cannot be of a uniform character.

The climate, however, is a remarkably healthy one. Happily, diseases such as fevers of an aggravated and malarious character, cholera and liver complaints, are unknown. Those diseases, so fatal and common in other tropical climates, could not well thrive, for owing to the geographical position of the group, being in the region of the Trade winds, it enjoys almost perpetual breezes. Calms are very rare, as, with the exception named, the area of the Islands being small, the sea breezes from all directions penetrate into every corner, and the miasma arising from swamps, usually so poisonous and fatal in hot climates, does not seem to cause any serious epidemics.

To Europeans who follow outdoor occupations the heat is no doubt rather distressing in the summer months, but agricultural and other work is regularly performed by both whites and blacks without any apparent ill effect to the strong and healthy constitution. After a few months' residence in Fiji, the

new arrival will lose much of his ruddy appearance; this is looked upon as the first stage which marks the progress of acclimatising the new settler.

Ardent spirits are decidedly injurious in this climate, as in all hot countries. During his seventeen years' experience in Fiji, the author can call to mind many robust constitutions ruined by the too free use of the bottle. The natives, who are prohibited by law from procuring spirits or other intoxicants, are healthy in the extreme.

The accompanying tables give the monthly results of the meteorological observations taken at Levuka from January 1875 to August 1882, and at Suva from September 1882 to December 1885. No corrections have been applied to the readings of the standard barometer. This course has been adopted for the purpose of enabling the majority of readers to see at a glance the actual readings, without having to trouble their minds with the corrections. To the scientific reader, who has before him the material for the necessary corrections required by the Royal Meteorological Society, the application thereof will be of the easiest possible character. Barometer by Negretti and Zambra, No. 1,043, error index and capillary +·006 in. Standard thermometer by same makers, and numbered 14,154. Rain gauge 8 inches in diameter, placed in an open space and fully exposed.

1875.

Months.	Mean Barometer as read.	Temperature.			Rainfall.		
		Highest.	Lowest.	Mean.	Total.	Greatest daily fall.	No. of rainy days.
	Ins.	°	°	°	Ins.	Ins.	
January	29·905	87	76	82	11·66	4·33	21
February	29·158 ?	87	76	82	9·82	1·77	21
March	29·652	85	76	80	23·98	3·80	25
April	29·949	84	75	79	18·95	6·97	21
May	30·012	83	75	79	6·86	1·31	17
June	30·012	82	71	78	16·06	5·29	21
July	30·021	81	73	76	2·21	0·56	16
August	30·018	79	65	78	2·62	0·73	14
September	30·018	82	67	78	8·00	2·99	16
October	30·013	83	76	79	7·07	2·17	13
November	29·671	83	73	78	7·21	4·35	18
December	29·889	84	76	80	5·05	2·12	15
Year.	29·860 ?	87	65	79·1	119·49	..	218

1876.

Months.	Mean Barometer as read.	Highest.	Lowest.	Mean.	Total.	Greatest daily fall.	No. of rainy days.
January	29·239 ?	86	78	82	10·82	4·94	21
February	29·565	92	75	84	8·76	1·91	21
March	29·826	85	76	81	17·39	4·56	26
April	29·916	83	73	79	13·54	4·52	16
May	30·015	81	74	78	2·64	0·55	18
June	30·022	83	72	77	2·42	1·37	14
July	30·019	81	70	75	1·32	0·32	12
August	30·020	80	72	75	5·55	1·38	18
September......	30·016	82	70	76	5·12	1·86	16
October	30·015	81	70	77	6·68	1·76	19
November	29·857	83	72	78	7·65	4·38	14
December	29·654	83	74	78	22·71	4·25	20
Year.	29·847 ?	92	70	78·3	104·60	..	215

1877.

Months.	Mean Barometer as read.	Temperature. Highest.	Temperature. Lowest.	Temperature. Mean.	Rainfall. Total.	Rainfall. Greatest daily fall.	Rainfall. No. of rainy days.
	Ins.	°	°	°	Ins.	Ins.	
January	29·924	91	69	82	12·40	4·43	14
February	29·998	92	73	82	9·29	1·77	16
March	29·991	90	71	81	12·67	2·23	21
April	30·003	91	72	80	4·12	0·97	17
May	30·122	91	68	82	0·76	0·14	11
June	30·157	89	65	75	6·77	2·14	19
July	30·157	85	62	74	7·16	2·63	15
August	30·118	84	62	72	11·04	2·98	14
September	30·206	82	65	74	2·79	2·03	6
October	30·177	85	66	76	5·47	2·22	10
November	30·112	89	68	79	0·03	0·01	3
December	30·053	91	73	81	0·88	0·27	10
Year.	30·085	92	62	78·2	73·38	..	156

1878.

January	30·071	86	78	82	8·52	2·46	17
February	30·086	86	76	82	5·37	1·84	18
March	30·050	86	77	81	16·09	3·17	21
April	30·142	84	74	79	17·18	3·10	25
May	30·175	83	71	79	1·74	0·41	12
June	30·209	81	73	77	0·20	0·06	7
July	30·207	82	67	75	1·38	0·41	12
August	30·226	80	70	75	2·86	1·45	9
September	30·258	79	71	76	0·89	0·31	9
October	30·198	81	71	76	3·75	1·10	14
November	30·130	82	74	78	11·35	2·10	21
December	30·078	84	75	80	3·31	0·59	15
Year.	30·153	86	67	78·3	72·64	..	180

1879.

January	30·030	86	77	81	15·29	3·85	23
February	30·050	85	76	80	12·64	4·26	20
March	30·116	87	78	82	11·42	3·08	20
April	30·141	87	71	81	12·97	1·98	26
May	30·149	85	73	80	7·67	1·96	14
June	30·206	87	73	78	4·21	1·05	17
July	30·223	83	72	78	5·60	2·52	12
August	30·259	83	70	76	2·44	0·45	17
September	30·233	82	66	77	4·89	1·18	20
October	30·192	84	72	78	8·94	3·42	11
November	30·125	85	73	80	4·84	1·25	14
December	30·029	85	74	80	6·17	1·04	16
Year.	30·146	87	66	79·3	97·08	..	210

1880.

Months.	Mean Barometer as read.	Temperature.			Rainfall.		
		Highest.	Lowest.	Mean.	Total.	Greatest daily fall.	No. of rainy days.
	Ins.	°	°	°	Ins.	Ins.	
January	29·962	87	78	82	14·02	3·37	20
February	30·073	87	75	81	7·62	2·34	20
March	30·091	89	73	82	13·62	2·93	17
April	30·148	86	72	79	22·35	5·34	23
May	30·137	89	68	80	5·91	1·95	12
June	30·093	88	69	78	6·45	3·02	18
July	30·108	85	66	76	5·83	1·08	21
August	30·132	84	67	76	10·66	6·92	14
September	30·124	87	67	75	2·60	0·62	8
October	30·108	89	68	77	20·29	7·92	16
November	30·000	89	72	79	9·47	2·98	20
December	29·976	93	73	81	15·52	5·80	19
Year.	30·079	93	66	78·8	134·34	..	208

1881.

January	29·899	93	74	83	19·94	4·16	26
February	29·929	90	73	81	19·96	4·67	23
March	30·017	93	72	82	11·64	2·30	22
April	30·074	91	72	82	8·00	5·80	10
May	30·114	88	69	78	2·13	0·43	25
June	30·117	88	69	79	2·94	2·34	7
July	30·080	86	67	77	9·46	3·77	16
August	30·152	87	65	77	14·19	5·38	19
September	30·131	88	68	79	6·14	1·83	16
October	30·114	88	66	80	8·95	5·88	7
November	30·013	92	71	83	10·43	2·14	20
December	29·925	89	71	81	22·11	4·66	22
Year.	30·047	93	65	80·2	135·89	..	213

1882.

January	29·849	91	71	82	11·80	4·30	22
February	29·980	94	70	83	12·77	2·24	16
March	29·951	91	72	81	11·78	1·20	23
April	30·049	90	71	82	2·72	0·58	15
May	30·042	91	68	80	22·59	4·65	20
June	30·100	88	62	78	1·40	0·75	8
July	30·121	86	68	75	8·25	3·92	15
August	30·137	87	68	80	3·88	1·01	7
September	30·111	87	65	77	3·31	0·75	13
October	30·165	86	64	78	5·82	2·04	17
November	30·003	87	68	81	28·73	5·70	20
December	29·919	90	70	83	10·69	2·09	18
Year.	30·036	94	62	80·4	103·74	..	194

1883.

Months.	Mean Barometer as read.	Temperature. Highest.	Temperature. Lowest.	Temperature. Mean.	Rainfall. Total.	Rainfall. Greatest daily fall.	Rainfall. No. of rainy days.
	Ins.	°	°	°	Ins.	Ins.	
January	29·909	91	68	83	7·31	2·17	17
February	29·917	86	68	80	13·25	1·90	25
March	29·943	90	70	82	9·08	1·33	21
April	30·036	89	68	80	9·12	2·59	20
May	30·091	87	67	78	4·84	3·38	10
June	30·094	85	63	75	12·25	4·23	20
July	30·140	85	63	74	2·23	0·84	13
August	30·142	85	63	74	7·39	3·10	18
September	30·106	85	61	75	3·70	2·04	12
October	30·114	85	64	76	7·17	1·53	14
November	30·029	88	65	79	18·05	3·42	17
December	29·958	87	70	79	14·46	4·01	27
Year.	30·040	91	61	77·9	108·85	..	214

1884.

January	29·978	88	70	80	4·40	1·54	18
February	29·959	87	70	80	18·77	7·42	27
March	30·027	87	72	82	15·59	4·22	26
April	30·060	85	70	79	8·71	3·90	18
May	30·091	85	66	76	6·96	1·49	19
June	30·144	85	63	76	2·58	1·02	13
July	30·155	81	63	73	2·46	0·95	18
August	30·150	83	60	73	5·52	2·34	14
September	30·174	81	62	73	13·43	2·07	23
October	30·179	83	62	76	0·51	0·17	9
November	30·066	85	67	79	9·86	2·68	18
December	30·007	87	70	82	3·29	0·90	16
Year.	30·083	88	60	77·4	92·08	..	219

1885.

January	29·915	87	70	81	12·81	2·15	27
February	29·993	88	73	83	5·62	1·99	18
March	29·963	86	77	82	9·88	2·02	25
April	30·011	87	69	81	10·69	2·11	27
May	30·157	86	67	77	6·03	2·07	24
June	30·181	82	64	75	0·83	0·18	24
July	30·142	82	63	74	2·55	0·70	21
August	30·132	78	62	71	9·00	2·50	28
September	30·193	77	62	72	6·64	2·09	22
October	30·199	80	63	75	3·47	1·00	13
November	30·112	83	67	77	3·51	1·57	17
December	30·048	87	70	80	5·32	2·36	19
Year.	30·087	88	62	77·3	76·35	..	265

NOTES ON THE FOREGOING TABLES, SHOWING WHEN THE GREATEST ATMOSPHERIC DISTURBANCES HAVE TAKEN PLACE.

1875. January 7th, at 9 a.m., the barometer registered 29·690 ins. with a strong breeze blowing from North. At 1 p.m. the reading was 29·621 ins., and the mercury continued to fall with increasing wind until 4 a.m. on the 8th, when the barometer reached its lowest reading, 29·070 ins., wind blowing with full hurricane force. In Levuka several houses were blown down and others damaged; vessels in the harbour suffered to a considerable extent. Her Majesty's surveying schooner *Beagle* was blown ashore, but was afterwards got off all right. A small cutter with one white man and several natives on board disappeared during the night, and was never again heard of.

The wind on this, as on nearly all occasions, blew in force from North to West, ending in the latter quarter. During these atmospheric disturbances the rainfall is very heavy, and while that particularly referred to was raging it was impracticable to expose the face or hands to the rain. This descended with such force that the exposed parts of painted houses were washed clean, leaving no trace of paint having ever been applied.

Heavy boats that had been laid up on the shores were rolled along before the wind as though they had been mere bundles of hay. Large trees snapped off like reeds, and others again were taken up by the roots.

1875, March 12th and 13th. A strong gale from the same quarter, but no great damage done. The next severe gale was felt on March 15th, 1876. Wind blew with considerable force from South to West by the North. This was felt more severely at Levuka than in other parts of the group. The southern portion of the group appears to have escaped it altogether.

1879, December 11th and 12th. Very heavy squalls and rain. The damage done on this occasion was very slight.

1883, March 12th and 13th. Barometer fell on the 12th to 29·750 ins. At 4 p.m. on the 13th the reading was 29·780 ins., showing unmistakable indications of a storm which doubtless passed to the North-west of this group.

1884, February 7th. The barometer was low, with fresh gale blowing from East-north-east. 4·37 ins. of rain fell.

The heaviest rainfall for the eleven years was 7·92 ins. on October 30th, 1882, 6 ins. of which fell between the hours of 11 a.m. and 8 p.m.

NOTE.—The instruments are in a large building occupied as Government Stores. One end of this building is taken off as a room 14 ft. by 14 ft. by 15 feet high from the floor. In this room there are three large doors and two large sashes, with thorough ventilation at all times both above the floor and under the ceiling. The instruments are placed on the inner dividing wall. The barometer cistern is 8 feet above the floor and 18 feet above sea-level; all the thermometers are 2 feet higher in a straight line on each side of the barometer. The rain-gauge is placed on the ridge of the building fitted with ½-inch lead pipe, having at the end communicating with the office a

um-tight brass tap. This plan has been adopted owing to not having per open space to expose the rain-gauge.

'he whole of the building is constructed of wood for walls and galvanised roof.

t my own house I have another complete set of instruments; the baro-er is in a good light in my library, and the thermometers are exposed in reen made on Stevenson's principle, but with rather better ventilation at top, the top being made on the same principle as the sides. I have had he instruments together in both positions, and found them to correspond tly, and have again frequently tested the readings at given times, and making the allowances necessary for the 87 feet difference in altitude een my house and the office found the reading to be the same.

PROCEEDINGS AT THE MEETINGS OF THE SOCIETY.

MAY 19TH, 1886.

Ordinary Meeting.

WILLIAM ELLIS, F.R.A.S., President, in the Chair.

WRENCE T. CAVE, 13 Lowndes Square, S.W.; and
EV. CLIFFORD MALDEN, M.A., St. Lawrence, Ventnor, Isle of Wight,
balloted for and duly elected Fellows of the Society.

ie Foreign Secretary read a letter from the Foreign Office forwarding copies cuments relative to the International Congress of Hydrology and Climatology, held at Biarritz in October next.

ie following Papers were read, viz.:—

'THE SEVERE WEATHER OF THE WINTER OF 1885-6." By CHARLES DING, F.R.Met.Soc. (p. 223.)

DESCRIPTION OF AN ALTAZIMUTH ANEMOMETER FOR CONTINUOUSLY RE-ING THE VERTICAL ANGLE AS WELL AS THE HORIZONTAL DIRECTION AND E OF THE WIND." By LOUIS M. CASELLA. (p. 246.)

EARTH TEMPERATURES, 1881-1885." By WILLIAM MARRIOTT, F.R.Met.Soc. 53.)

NOTE ON THE AFTER-GLOWS OF 1883-1884." By ARTHUR W. CLAYDEN, , F.R.Met.Soc. (p. 265.)

JUNE 16TH, 1886.

Ordinary Meeting.

WILLIAM ELLIS, F.R.A.S., President, in the Chair.

v. JOHN ROBERTS BOYLE, Normanton Terrace, Newcastle-on-Tyne; and
BERESFORD DE LA POER WALL, M.A., Hamilton and Western District
College, Hamilton, Victoria,
balloted for and duly elected Fellows of the Society.

The following Papers were read, viz.:—

"NOTE ON A SUDDEN SQUALL, JANUARY 13TH, 1886." By ROBERT H. SCOTT, M.A., F.R.S., F.R.Met.Soc.

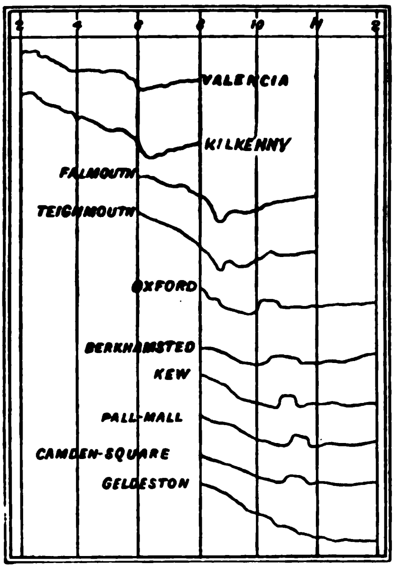
NEARLY nine years ago, November 1877, I had the honour to submit to the Society a note on a remarkable barometrical oscillation which had occurred in the North of the Kingdom on January 30th, 1876.[1] This apparently was a sort of whirlwind, or as the Americans call it, tornado, but as it happened during the forenoon of a Sunday, the records of the accompanying weather were not as complete as they might have been on a week day. On the present occasion the accounts are much fuller.

My attention was first drawn to this squall by Mr. T. E. Allen, who noticed that the barogram at Falmouth showed a sudden temporary fall of the barometer, while the record for Kew about two hours later showed the converse change, a sudden temporary rise of the barometer. The contrast between the two records is strongly marked in the original photographs, but it does not come out at all so clearly when the curves are pantagraphed down to the size given in the accompanying figure.

However, I at once began to collect other barograms, and it soon was manifest that the peculiarity of the phenomenon was confined to the South of England. In the accompanying figure the records are reproduced from Valencia; Kilkenny (Richard's); Falmouth; Oxford, Radcliffe Observatory; Kew; Pall Mall, Messrs. Lund and Blockley (Redier's); Camden Town, Mr. Symons (Redier); Geldeston, Mr. Dowson (Redier's). Where the type of barograph is not mentioned, the instrument is photographic.

Records of the squall were obtained from several of the stations in connection with the Meteorological Office and the Royal Meteorological Society, and in addition a large number were supplied by Mr. Symons from his own circle of correspondents.

On examination of the figure, it will be found that the Irish stations show no



Barograms—January 13th, 1886.

[1] *Quarterly Journal*, Vol. IV. p. 73.

very remarkable oscillations of pressure, but when we come to Falmouth we notice that at 8 a.m. the mercury began to fall very rapidly, and by 8.20 it had sunk 0·120 in.; it then remained steady for ten minutes, and rose even more rapidly, with a sudden change of wind from West-south-west to West-north-west, and an equally sudden fall of temperature of about 5°·5, the wet bulb being more affected than the dry. At this station the wind velocity, about 40 miles an hour, did not change. At Oxford, which was the nearest station I could find to Falmouth, possessing a barograph *in action*, the sudden fall of the barometer does not appear, but just before 10 a.m. the barogram shows a sudden rise, followed after about half-an-hour by a fall. The rise of the barometer was accompanied by a squall between 9.45 and 9.55 a.m., the wind shifting from South-west by West to North-west by North, and the temperature falling about 6°.

At Kew the appearances are similar to those of Oxford, and they are completely supported by the records of the Redier's instruments at Pall Mall and Camden Town. The mercury in the barometer rose rapidly at 10.40 a.m., and the subsequent fall took place after a shorter interval than was the case at Oxford. There too the rise of the barometer was accompanied by the sudden fall of temperature coming with the shift of wind to the Northward in the squall.

At Greenwich the barograph was unfortunately out of action at the time, but the other phenomena of wind direction and sudden change of temperature were reproduced, and in addition the Thomson's electrograph showed a sudden and marked change of potential at the epoch of the shift of wind: this is precisely similar to the change of the same element at the moment of passage of the minimum over Kew in the storm of March 12th, 1876.[1]

After passing London we have no further barographic record of the movement, for it will be seen that the barogram from Geldeston, near Beccles, shows no trace of the disturbance.

As to the records of the squall, they are numerous but not very precise. The occurrence took place in the interval between the regular hours of observation, and no trace of it is to be seen in the daily weather chart for 8 a.m. on the 13th. In fact the figure shows that the two Irish stations felt little, if anything, of the sudden barometrical oscillation.

The *Times* of January 14th contains the following paragraph:—"A fierce gale from the South-west, accompanied by a thunderstorm, passed over the Midland and Western Counties yesterday. Trees were uprooted, and in some instances the upper parts of houses wrecked."

The best of all the accounts is that of Mr. H. Southall, F.R.Met.Soc., from Ross, in Herefordshire. He says, "The violence of the squall which suddenly burst upon us at 8.55 a.m. was extraordinary. A short time before I saw a black cloud apparently 8 or 10 miles to the North-west, but as the whole sky was very stormy looking and rain had already fallen, I did not anticipate the fury with which in so short a time it assailed us. The barometer had fallen 0·82 in. in twenty four hours (much more rapidly at last), the temperature was 46° (a great increase during the night), and the wind appeared to be light from South-west. With scarcely any further warning a storm of rain and wind enveloped us, tearing large branches from trees, blowing in windows, and in some cases unroofing buildings. It lasted only a few minutes."

Of the MS. reports, those from Ireland and Scotland only mention the weather as "squally with hail showers," in fact all the telegraphic reports put down "squally" at each hour of observation, but Hurst Castle is the only station at which the squall which forms the subject of this paper is specially noticed. In all, I have about fifty reports from England and Wales, in addition to what has been stated above; the most important of these are enumerated in the order of the recorded time of occurrence.

St. David's, 8 a.m. Terrific squalls, hail, wind hurricane force.

Stokesay, near Craven Arms (Salop), 8.25 a.m. Wind suddenly changed from South-west to North-west, with heavy hail till 8.45 a.m.

Woolstaston (Salop), 8.25 to 8.40 a.m.

Orleton (Worcestershire), 8.30 a.m.

Cheadle, 8.30 a.m.

Cheltenham. Squall with heavy rain for ten minutes, at 9 a.m.

[1] *Quarterly Journal*, Vol. III. p. 169.

Stroud, 9.15 a.m.
Leicester. Great storm at 9.15 a.m.
Coston (Leicestershire), 9.30 a.m.
Cirencester. Gale, amounting to a hurricane, for a few minutes at 9.30 a.m., during which time several trees fell.
Babbacombe, 9.55 a.m.
Teignmouth, 10 a.m.
Banbury, 10 a.m.
Harestock (Hants), 10 a.m.
Ketton, near Stamford, 10 a.m.
Reading, 10.15 a.m.
Great Berkhampstead. A heavy downpour of rain, immediately followed by a short but very heavy fall of small hail, and accompanied by a violent wind, took place between 10.17 and 10.21 a.m. Mean velocity of wind for one half minute during this squall, equal to a rate of 48 miles an hour.
Finchley. Between 10.30 and 11 a.m., wind veering suddenly from South-west to North-west.
Cooper's Hill, Staines. Hail squall 10.35.
Southampton. A sudden violent storm of wind with rain at 10.30 a.m., which lasted about 15 minutes.
Hurst Castle, 10.30 a.m.
Southbourne (Hants). Sudden gale from West-north-west at 10.50 a.m., lasting only 8 minutes.
St. Lawrence (Isle of Wight). Lasting 10 minutes at 10.50 a.m.
Beddington, 11.12. Squall, *Eurydice* sort.
Hythe. Heavy rain squall at noon.

On plotting these statements on a map we find a motion from West-north-west to East-south-east shown generally. Some of the statements, however, do not harmonise quite well with each other.

The squall was also reported from the following places, but without any statement as to time of occurrence :—

Llanfrechfa (Monmouthshire). Wednesbury : "A steam travelling crane, with its frame work 50 or 60 feet high, was blown from the embankment on which it stood into the Old Park Road," Birmingham. Stratford-on-Avon : "The Great Western station was unroofed." Langton Herring, near Weymouth : "A gale doing considerable damage to the boats on Chesil Beach, and uprooting trees in this neighbourhood." Littlehampton, and Wallington, near Croydon.

DISCUSSION.

Mr. Mawley said that he was just about to leave his house on the morning in question, when he noticed that the wind had suddenly become unusually high, and so went at once to the recording instrument of his Beckley's anemograph, to which he had attached a dial divided to hundredths of a mile. He found on reaching the instrument that the rate at which the wind was travelling during the first 15 seconds was 30 miles an hour, and that for the next half minute the mean rate was 48 miles an hour. Yet in the next 15 seconds only 15 miles an hour was indicated, and the highest rate observed after this time was but 17 miles an hour. These particulars showed not only the remarkable briefness of this squall, but also the very sudden way in which the wind dropped as the squall passed off.

Mr. Symons pointed out how extremely desirable it was that observers should keep correct time, and be careful to note the exact moment of occurrence of the various phenomena which visited them. The barometer curve shown for Teignmouth appeared to be wrong as regards time.

Mr. Strachan inquired whether Greenwich time was used at all the stations.

Mr. C. Harding referred to the account given of this squall in the *Standard* newspaper of January 14th, 16th, and 19th, and quoted several extracts from the information collected. He stated that he had mapped the progress of this squall, and its course seems to have been from West-north-west to East-south-east, and its rate of motion about 70 miles an hour. It was, however, very unsafe in phenomena of this description to be at all certain as to the rate of travel, for the line of squalls extended over a considerable area of the country, and the squalls

were of a similar character with respect to sudden change of wind and other accompaniments, being coincident in time at places considerably removed from each other.

Mr. ARCHIBALD said that this squall seemed to be very similar to those experienced with the "North-westers" of India. He noticed that the Greenwich anemograph trace showed a very sudden change in the direction of the wind.

Mr. CURTIS said the squall appeared to be due to the passage of a subsidiary depression, which in many respects was very similar to the one which caused the loss of the *Eurydice*, and which Mr. Abercromby had called a V-shaped depression. The most marked feature of the phenomena appeared to be the sudden rise of the barometer which accompanied the veering of the wind to the North-west. At the more western stations this followed directly upon an equally sudden fall, and was at once succeeded by a fresh but gradual decrease. At the eastern stations, on the contrary, no acceleration of the fall preceded the rise, but after a short interval it was followed by a very sudden drop of the mercury. This might assist in tracing the path of the depression. The wind had not backed anywhere in Great Britain, but as far north as Aberdeen it had veered. The discrepancy in the time at Teignmouth, referred to, might be due either to error of clock or to the use of local time at that station ; the curve was correctly copied from the original. At Falmouth, Greenwich mean time was used.

Mr. GASTER remarked that this squall was caused by a broad North-westerly current of wind advancing with rapidity and having a very level South-east margin. It would therefore inpinge on the previously existing Westerly current at an angle of about 45°, and in this way a series of squalls would be developed along the line of contact, causing the *appearance* of a single squall travelling from place to place with extreme rapidity. The fact would be that numerous squalls, not necessarily of the same character, would be developed in rapid succession at the stations over which the contact took place. Hence the more care is necessary in deciding whether phenomena occurring in chronological order at a line of stations are the result of one travelling, or of several independent, disturbances.

Mr. WHIPPLE appealed to observers to procure Richard barographs, in order that by recording the occurrence of sudden oscillations due to squalls, such as the one referred to in the paper, they might assist those investigators who were engaged in determining the laws of weather progression.

Mr. SCOTT, in reply, said that possibly the instrument at Teignmouth, a Richard barograph, was wrong in time.

The PRESIDENT (Mr. Ellis) said that this inquiry well illustrated the advantage of possessing continuous records, for without such it could not have been made. Many otherwise excellent barographs are arranged to give only an intermittent record, as once in ten or twenty minutes, and in some cases less frequently, which is insufficient for the proper investigation of phenomena of the kind dealt with in the paper.

"THE FLOODS OF MAY, 1886." By WILLIAM MARRIOTT, F.R.Met.Soc, and F. GASTER, F.R.Met.Soc. (p. 269.)

"ON ATMOSPHERIC PRESSURE AND ITS EFFECT ON THE TIDAL WAVE." By Capt. W. N. GREENWOOD, F.R.Met.Soc. (p. 283.)

"METEOROLOGICAL RESULTS AT LEVUKA AND SUVA, 1875-1885, WITH NOTES ON THE CLIMATE OF FIJI." By J. D. W. VAUGHAN, F.R.Met.Soc. (p. 285.)

CORRESPONDENCE AND NOTES.

THE CLIMATE OF DUBLIN. By J. W. MOORE, M.D., F.R.Met.Soc.

AT the Meeting of the Sub-Section of State Medicine of the Academy of Medicine in Ireland, on April 21st, 1886, Dr. Moore read a paper on the Climate

of Dublin, based on twenty years' observations, 1865-1884, of which the following is an abstract:—

The climate of Dublin is, in the fullest sense, an *insular* one, free from extremes of heat and cold, except on very rare occasions; and characterised by a moderate rainfall (about 28 inches) annually, which is distributed, however, over a large number of days (about 195 in each year). Clouded skies, a high degree of humidity, and a prevalence of brisk winds—chiefly from Westerly points—make up the climatology of the Irish capital.

In common with the rest of the British Islands, Dublin owes its mild equable climate to the proximity of the North Atlantic Ocean and its surface current of warm water—the Gulf Stream. But local natural advantages as regards situation exercise a further beneficial effect on the climate of Dublin. A few miles south of the city lies a range of hills, with summits varying in height from 1,000 to more than 2,500 feet. This mountain chain intercepts the vapour-laden winds at all points between South-south-east and South-west, and so the rainfall is diminished and the sky is comparatively cleared during the continuance of the Southerly and South-westerly winds which so frequently prevail. The absence of any very high ground to the northward of the city—with the exception of the Hill of Howth—which rises, however, only to 563 feet—also prevents excessive precipitation with South-west winds. It is true that with Easterly (South-east to North-east or North) winds the precipitation (often in the form of hail, and in winter of sleet or snow) in and about Dublin exceeds that which occurs at such a time inland or on the Atlantic coasts. Were it not for this "lee-shore" condensation the Dublin rainfall would be considerably smaller even than it is.

The second local feature which ameliorates the climate of the capital is the proximity of the sea to the eastward of the city. The keen, dry, searching Easterly winds of winter and spring are much softened in their passage across the Irish Sea, so that during their prevalence the thermometer occasionally stands some 5° or upwards higher in Dublin than it does at Holyhead, although this latter place is actually on the sea. It is true that the converse holds good during Westerly and North-westerly winds, when severe frost sometimes occurs in winter in Dublin, while the thermometer remains decidedly above the freezing point at Holyhead. Yet these latter winds are never so piercingly cold and parching as those from Easterly points. Nor is it in winter merely that the Irish Sea confers a benefit upon Dublin. In calm, clear weather in summer time, no sooner has the sun mounted high in the heavens than a cool refreshing sea-breeze sets in towards the land, so that consequently extreme or oppressive heat is rarely experienced. Indeed, an oppressive atmosphere happens only when a damp warm South-west wind is blowing, with a more or less clouded sky. Temperatures above 80° in the shade in Dublin nearly always coincide with winds off the land, from some point between South and West, and a clear or only slightly clouded sky.

Among climatic phenomena, the infrequency of thunderstorms and the relative frequency of hail-showers in Dublin are worthy of note. In winter, fog and frost often prevail in the city when a Northerly breeze is blowing along the coast, accompanied with a higher temperature and perhaps showers of rain. Lastly, in summer, with a Westerly wind, heavy showers fall at times in the valley of the Liffey, while the neighbouring higher lands enjoy dry weather.

The accompanying Tables give the monthly, yearly, and average temperature and rainfall for the twenty years 1865-1884. The temperature values are the means of the daily maximum and minimum readings.

The author supplies the following information as to the exposure of the thermometers, &c. Prior to 1867, the thermometers were exposed in the window of his rooms in Trinity College facing East, at an elevation of 6 feet above the ground. Since October 1867, the thermometers have been placed in a modified Stevenson screen under the wall of a small garden facing North-north-east. The wall is about 9 feet high, and the garden measures 90 feet long, and 23 feet wide, the screen is distant 64 feet from the dwelling house and 27 feet from the stable. Prior to 1870 the barometer observations are not as trustworthy as subsequently, as at that date an excellent barometer by Adie was obtained from the Meteorological Office.

TABLE I.

MONTHLY, YEARLY, AND AVERAGE MEAN TEMPERATURE OF THE AIR IN DUBLIN, FOR THE TWENTY YEARS, 1865–1884.

Year.	Jan.	Feb.	Mar.	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Mean.
	°	°	°	°	°	°	°	°	°	°	°	°	°
1865	37·8	41·1	41·2	50·4	53·6	61·0	62·0	59·6	61·4	50·7	45·1	46·2	50·8
1866	43·8	40·3	42·0	47·9	50·1	57·8	61·0	58·3	53·0	51·3	46·1	45·1	49·7
1867	35·7	45·7	39·0	49·9	52·0	58·8	58·6	61·3	56·4	50 3	43·2	42·0	49·4
1868	41·9	44·8	47·3	50·1	55·8	60·5	63·5	60·8	57·9	48·0	43·3	44·7	51·6
1869	44·1	46·7	41·2	50·0	48·2	56·0	63·2	59·4	57·1	51·8	45·0	39·8	50·2
1870	41·3	40·5	43·5	49·8	53·9	59·6	63·3	60·5	57·2	50·3	42·2	37·3	50·0
1871	37·9	46·1	46·6	49·6	53·9	57·1	60·4	62·0	54·6	51·6	43·2	42·1	50·4
1872	42·3	45·9	45·9	48·4	50·4	56·2	62·4	60·0	55·7	47·6	44·4	42·1	50·1
1873	43·0	37·9	42·9	47·3	51·9	59·1	61·5	60·2	54·1	48·2	45·7	45·5	49·8
1874	43·6	42·5	36·7	50·4	50·8	57·9	61·8	59·1	55·8	50·4	46·5	36·8	50·2
1875	46·3	41·0	43·9	48·0	54·9	56·5	58·2	61·1	58·2	50·1	44·6	41·2	50·3
1876	43·1	42·4	41·1	47·1	50·5	57·1	62·1	60·1	54·9	53·1	44·4	44·6	50·0
1877	43·7	44·7	42·5	46·1	49·7	58·5	58·9	58·6	53·4	51·2	45·9	42·3	49·6
1878	43·2	44·6	44·5	48·9	53·5	58·2	62·1	60·7	56·7	51·6	38·2	32·8	49·6
1879	35·3	40·1	42·5	44·5	48·8	55·9	57·2	57·7	54·3	49·7	43·9	37·9	47·3
1880	39·7	45·0	45·4	47·8	52·1	57·1	58·9	61·5	58·6	45·4	44·3	42·4	49·9
1881	33·2	40·6	43·2	45·6	53·5	56·4	61·0	57·0	54·6	48·1	50·3	40·7	48·7
1882	44·7	46·2	46·9	47·1	53·2	55·8	59·5	59·2	53·0	50·1	43·6	38·2	49·8
1883	43·2	43·6	39·0	46·7	51·7	56·4	57·9	59·4	55·3	50·0	44·4	42·6	49·2
1884	45·2	43·4	45·4	46·4	52·6	57·9	60·8	61·5	58·0	50·3	43·9	41·6	50·6
Average.	41·4	43·2	43·5	48·1	52·1	57·7	60·7	59·9	56·0	50·0	44·4	41·3	49·9

TABLE II.

MONTHLY AND YEARLY RAINFALL AT DUBLIN DURING THE TWENTY YEARS 1865 TO 1884.

Year.	Jan.	Feb.	Mar.	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Total.
	In.	In.	In.	In.	In.	In.	In.	In.	In.	In.	In.	In.	In.
1865	1·89	2·32	1·48	1·30	3·41	·73	3·63	3·39	·06	3·06	3·33	2·86	27·46
1866	1·89	2·06	3·63	2·12	1·81	3·57	1·01	2·17	2·74	1·73	1·49	1·66	25·88
1867	3·09	1·81	4·97	2·18	2·80	1·12	3·44	1·77	1·18	2·85	1·26	·77	27·24
1868	2·64	1·23	1·65	1·93	·89	·68	·74	4·74	2·68	·86	2·15	4·75	24·94
1869	4·26	1·27	2·42	1·49	5·42	·79	·74	1·56	3·96	1·07	1·90	2·59	27·56
1870	2·35	1·44	1·70	·84	1·16	·80	·54	1·51	1·63	5·19	1·22	2·39	20·86
1871	2·62	1·65	·82	3·16	·38	2·26	4·39	1·06	4·05	2·92	1·26	·80	25·37
1872	2·87	2·56	2·42	2·66	2·16	3·28	1·10	4·30	2·46	3·42	3·41	4·93	35·57
1873	2·65	·92	2·39	·30	·91	·94	3·41	3·94	2·37	3·09	2·01	·69	23·82
1874	2·02	2·68	·95	1·32	1·75	·40	2·51	4·95	1·71	2·51	3·18	3·21	27·19
1875	2·14	2·48	1·04	1·01	1·07	2·99	2·75	1·88	3·18	7·05	3·05	1·31	29·95
1876	·41	3·01	2·16	2·60	·80	1·26	1·34	2·26	3·15	4·50	3·61	7·56	32·66
1877	4·32	1·56	2·74	4·71	2·34	·92	3·30	3·54	1·80	2·15	2·44	2·33	32·15
1878	1·56	1·58	1·16	2·35	4·54	5·06	·65	4·64	1·68	2·09	1·34	1·61	28·26
1879	1·71	3·71	1·83	2·00	2·05	4·05	4·19	3·70	2·04	1·32	1·25	1·01	28·86
1880	·56	2·58	3·13	1·83	·85	2·17	6·09	1·40	2·06	7·36	3·23	3·25	34·51
1881	1·37	2·88	1·88	1·33	1·53	2·67	1·86	4·74	1·60	3·47	2·17	1·53	27·03
1882	1·48	1·86	2·26	3·52	1·53	2·39	3·72	1·87	2·62	2·80	3·34	3·78	31·18
1883	2·68	3·75	1·06	2·27	2·02	1·93	2·22	3·31	3·64	2·20	3·07	1·26	29·35
1884	2·36	3·52	1·86	1·53	1·36	1·25	2·35	·78	1·21	·83	1·41	2·01	20·47
Average.	2·24	2·24	2·08	2·03	1·94	1·96	2·50	2·88	2·29	3·02	2·31	2·52	28·01

General Characters of the Summer Monsoon. By H. F. Blanford, F.R.S., F.R.Met.Soc.

Mr. Blanford, in his Paper on "The Rainfall of India," gives the following brief description of the general characters of the summer monsoon, in so far as they affect those of the rainfall of the Indian area[1]:—

The general fact that the summer monsoon is due to differential action of the sun on the land of Southern Asia, to the heating of the land surface and the superincumbent atmosphere, and the consequent formation of a barometric depression over the land, towards which currents of air set in chiefly from the neighbouring seas, has long been one of the standing and familiar truths of meteorology. An error which still occasionally finds place in popular treatises, but which has long disappeared from those having any pretension to authority, is that the goal of the Indian monsoon is situated in Central Asia; the existence of an impassable barrier in the Himalayan chain and the great plateau of Thibet having been somewhat unaccountably disregarded. It is, indeed, true that, rarely and exceptionally, a rain or snow precipitating current penetrates far into the Himalaya, such precipitation having been recorded on one or two occasions in recent years at Leh and in the interior of Lahoul; but, with such rare exceptions, the winter and spring, and not the summer, are the seasons of precipitation on all but the outermost and most southern ranges of the Himalaya; and since the condensation of water vapour, as cloud, snow or rain, is the necessary concomitant and indication of an actively ascending current, and the goal and terminus of every horizontal air current must be the place of its ascent, we may justly regard Northern India as the goal of the local monsoon.

So rapidly does the differential action of the sun on the land surface manifest itself in the early months of the year, that, so early as February, the barometric pressure in the interior of the peninsula begins to fall below that of the surrounding seas. This depression speedily extends northwards, and in March and April the region of greatest heat is situated in the Deccan, Central India, and Chutia Nagpur; the seat of lowest pressure being established on the eastern margin of the most heated tract, viz. in Chutia Nagpur or Northern Bengal. The influx of sea air, that follows immediately on this disturbance of atmospheric equilibrium, is practically restricted to the south and east of the Indian Peninsula and Bengal, the consequence being the production of the short-lived local storms and showers as the characteristic form of the spring rainfall.

It was pointed out by Maury, and I have quoted his remarks with general acquiescence in my own description of the Meteorology of India, that the winds which begin in February as sea winds, merely on the coast of the Sunderbunds, are gradually drawn in the subsequent months from greater distances at sea; and the wind table of the Bay of Bengal, drawn up by Lieutenant Cornelissen and reproduced in the *Indian Meteorologist's Vade-Mecum* (p. 182), shows that the predominance of winds from between south and west is first established in the north of the Bay and extends gradually southwards. But, as Mr. Eliot has emphatically pointed out, in his recently-published *Memoir on South-western Monsoon Storms*, "the northward extension of the South-east Trades across the Equator, and their continuation up the Bay, is a meteorological phenomenon of a different order of magnitude and intensity from that of the establishment and gradual intensification of the local sea winds at the head of the Bay and on the Bengal coast, in February and the hot weather months," and he regards this extension of the Southern Trades as the distinctive feature of the summer monsoon. That the setting in of the monsoon rains is a distinct and individualised phenomenon, to a certain extent catastrophic in character, and not merely the gradual intensification of the Southerly winds of the early summer months, has long been recognised by popular observation, and in the popular expression the "burst of the monsoon"; and I have myself more than once pointed to the fact in previous writings, though less emphatically than Mr. Eliot has done in the passage above quoted. It has also long been known from the descriptions of Dampier, Basil Hall, and others, that during the South-west monsoon the South-east Trades are frequently continuous across the Equator; and it is very likely

[1] *Indian Meteorological Memoirs.* Vol. III. Part I. p. 72.

that it is the linking up of the wind currents on the opposite sides of the Equator that determines the rush of saturated air that ushers in the monsoon rains. Nevertheless, the fact has been called in question by Dr. Mühry, who regards the South-west monsoon of Indian seas as a mere " detraction " or diversion of the lowest portion of the North-east Trade, and has endeavoured to show that the belt of equatorial calms extends uninterruptedly around the earth in the monsoon region as elsewhere, with but a slight annual shifting of its position. That his view of the South-west monsoon, as thus expressed, is erroneous, and rests on a misapprehension of an observation of Colonel Sykes, and that he altogether under-estimates the vertical thickness of the summer monsoon, I have endeavoured to show elsewhere. But that the equatorial belt of constant rainfall exists across the monsoon region, and is not bodily transferred northwards to India and southwards to Australia with the annual march of the sun in declination, is a well-established fact, and has been amply confirmed by the numerous rainfall registers of the Malay Archipelago, obtained, during the last five years, by the exertions of the late Dr. Bergsma. These registers show that, while in the neighbourhood of the Equator the season of the heaviest and most frequent rainfall is from November to January (the former being the epoch of maximum in the North, the latter in the South of the line), there is no month in which the precipitation does not amount to at least three or four per cent. of the annual total. In fact, during the monsoon the whole region between the Equator and the Himalaya is more or less one of precipitation, and may be regarded rather as an extension and broadening out of the normal equatorial rainy zone, with a northward transfer of its maximum and a partial concentration in Northern India, rather than a bodily transfer of the zone northwards to Southern Asia. This view is quite consistent with the facts deduced in the foregoing discussion, viz. the double maximum of Ceylon, Travancore, Tenasserim and the Bay Islands ; and it will be found greatly to facilitate the comprehension of many characteristic features of the monsoon, such as its oscillations, which Mr. Eliot more especially has described in several of his writings in this serial, and those well-known vicissitudes in the rainfall of India which will be treated of at length in the second part of this memoir.

The linking-up of the South-east Trades with the South-west monsoon in a continuous stream of air is not by any means constant, nor, I think, a very frequent condition even during the height of the monsoon ; as appears from the table drawn up by Lieutenant Cornelissen (above referred to), and also from the wind charts which are now preparing for publication by the Indian Meteorological Office. Nor even, as would seem from the logs given by Mr. Eliot in his *Memoirs on Cyclones*, while a cyclone is raging in the Bay of Bengal, at a time, therefore, when the monsoon current which feeds the cyclone is at its strongest, do ships crossing the line always find the South-east Trade veering to South and then to South-west. On the contrary, in the immediate neighbourhood of the line, and as far north as Ceylon, the winds appear to be, as a rule, more westerly than in the Bay of Bengal, West and West-south-west being by far the most frequent entries in the logs, and these winds are variable and squally, very different in character from the Trade winds, and frequently accompanied with heavy rain or squalls of rain, implying no small amount of local convection.

Instead, then, of the monsoon being simply a prolongation of the Trades, the case would rather seem to be that most frequently it originates in this variable, but on the whole westerly and rainy, current, which is doubtless fed by the South-east Trades, and consists of nearly saturated air ; but it represents only a portion of the air poured by the Southern Trade winds into the Equatorial region, the remainder ascending convectively, precisely as in the Atlantic Doldrums. Nor is the monsoon drawn from this source alone. It is probably recruited, to a very considerable extent, from more northern latitudes, especially during fine intervals, when the current is slacker and the rainfall on the Indian mainland less copious ; and it is to the varying degrees in which the two sources of supply are respectively drawn upon to furnish the indraught that I would attribute the variations of the rainfall during the progress of the season, and those more important vicissitudes of different years to which I shall have to draw attention in the sequel.

Rain does not fall continuously or steadily in any part of India during the rainy season. In the wettest tracts indeed, such as the Western Ghats, Eastern Bengal, Cachar and Arakan, there are very few absolutely rainless days in July

and August; but even in these, sometimes for several days in succession, an afternoon shower represents the whole rainfall of the day; and, as a general rule, in Northern India the rainy season is made up of periods of two or three days with heavy rain, alternating with more or less similar intervals of comparatively fine weather; the fine intervals increasing in length and serenity as we approach the dry tracts in North-western and Southern India. These alternations of fair and wet weather coincide with barometric oscillations, which affect simultaneously and pretty equably either the greater part of India, or it may be only the Northern, Western or Eastern division, but always a great extent of country; and their amplitude is greater in Northern than in Southern India, thus tending alternately to increase or diminish the barometric gradient that favours the Southerly monsoon. As a rule, the barometer falls during the finer intervals and rises with the rainfall. The cause and nature of these oscillations are still but little understood. They are not restricted to the rainy season, but occur at all times of the year, and are perhaps greatest just before the setting in of the rains. They have no *necessary* connection with the formation and passage of cyclonic storms, but a downward oscillation is frequently the precursor of one of these storms.

During the breaks in the rains the winds of North-western India are frequently from the West and sometimes even from the North-west; and, as I have pointed out elsewhere, are similar in character, and probably in their origin, to the normal land winds of the spring. Occasionally they continued to blow for several weeks, even during the height of the ordinary monsoon season (in July and August), and they then exclude the rain-bearing current from the greater part of Northern, Central and Western India. When thus prolonged, the draught that accompanies them is always prejudicial to the crops on the higher and therefore drier lands; but, provided good rain has fallen at the beginning of the season, and that they are followed by another general downpour in September, the destruction is not of a disastrous character. A noteworthy barometric feature, which is the invariable accompaniment of these winds when they extend far to the Eastward and Southward, is a relative rise of pressure in Western India, causing the isobars in Rajputana to advance to the North, and partially or completely to interrupt the trough of low pressure, which is shown on the normal isobaric charts of the summer months, extending from Chutia Nagpur to the Punjab and Upper Sind. At the same time the isobars run more obliquely (from North-west to South-east) across Central India and the peninsula. These features have been frequently noticed in the annual Reports on the Meteorology of India as characteristic of periods of drought.

The greater part of the rainfall of the summer monsoon is more or less sporadic, and accompanied with but slight local disturbance of the normal distribution of pressure; being most frequent and regular in and immediately around the eastern half of the trough of low pressure that lies between the two branches of the monsoon. This includes Lower Bengal, Chutia Nagpur, Orissa, the greater part of the Central Provinces, and the numerous tributary states lying between. It is the region wherein the average fall exceeds forty inches. But the heaviest falls are those which accompany the passage of the cyclonic storms, which we now know to constitute a frequent and characteristic feature of the summer monsoon. Many of these have been described and illustrated in the annual Reports on the Meteorology of India, and some at more length by Mr. John Eliot in previous volumes of these Memoirs; and in the sixth memoir of the second volume he has given an admirable summary of their characteristic features and tracks, and has pointed out wherein they differ from the more violent and destructive storms of the transition periods (May and October to November). That their existence had been ignored or rather was unknown until within recent years, and that the annual distribution of cyclones was believed to have a double maximum (corresponding to the transition periods), is now fully explained. Mr. Eliot has shown that this is due to their affecting a greater depth of the atmosphere, occurring, as they do, when the summer monsoon is at its height and its greatest vertical thickness. Consequently, the horizontal movement of the winds is less violent and the barometric depression at their centre but small, although the volume of air poured in, if measured by the quantity of water condensed and precipitated, is at least as great as in the storms of the transition periods; and the vortices have greater durability, being less obstructed and impeded by the irregularities of the land surface over which they pass.

RECENT PUBLICATIONS.

American Meteorological Journal. A Monthly Review of Meteorology, Medical Climatology and Geography. Vol. III. Nos. 3-4, July and August 1886. 8vo.

Contains:—Cyclones, Anticyclones and Pericyclones, by W. M. Davis (2 pp.). —Waterspouts on the Gulf Stream in winter, by H. B. Gibson (8 pp.). About 30 per cent. of the Waterspouts occur in the cold months, and generally in the south-western part of the area of low pressure. In the warm months they generally appear in the south-eastern quadrant, the same as is characterised by thunderstorms on land.—The Origin of the Red Glows, by Rev. S. Bishop (12 pp.). —On Vertical Currents in Cyclones (17 pp.).—On the Method of Cloud Formation in Cyclones, by H. H. Clayton (4 pp.).

Annuaire de la Société Météorologique de France. 34me Année. 1886, May. 4to.

Contains:—De la marée atmosphérique, par M. Hauvel (6 pp.).—Notice sur l'Observatoire Gruby, par E. Cassé (3 pp.).—La nébulosité et l'héliographe de Campbell, par P. Cœurdevache (2 pp.).

Annual Report of the Board of Regents of the Smithsonian Institution for the Year 1884. 8vo. 1885. xxxvii. + 904 pp.

The General Appendix contains a record of scientific progress during 1884. That on Meteorology (176 pp.) has been prepared by Prof. Cleveland Abbe, and consists of a series of short abstracts and notes relative to the principal meteorological items that have been published up to the end of 1884. The value of this article is greatly enhanced by a copious index, and also by a Bibliography of Meteorology for 1884.

Archives des Sciences physiques et naturelles. Tome XIV. July and November 1885. 8vo.

This contains two papers by M. A. Kammermann, of the Geneva Observatory, entitled (1) Première étude sur le minimum de nuit (49 pp.); and (2) Le thermomètre à boule mouillée et son emploi pour la prévision du temps (10 pp.).

British Rainfall, 1885. On the Distribution of Rain over the British Isles during the Year 1885, as observed at more than 2,000 Stations in Great Britain and Ireland, with Articles upon various branches of Rainfall work. Compiled by G. J. Symons, F.R.S. 8vo. 1886. 278 pp. and 4 plates.

The year 1885 was on the average of the whole country a dry year, but by no means remarkably so. The largest rainfall was 197·92 ins. at The Stye, in Cumberland, and the least 16·73 ins. at Leith. In addition to the usual information and tables respecting the rainfall during the year, there are articles on the following subjects:—Dr. Wild on the influence of dimensions and position upon the indications of rain gauges (10 pp. and plate).—On the Relative Fall of Rain during the Day and during the Night (4 pp.). From the results of twenty years' observations at Camden Square, it appears that in winter the nights are wetter than the days; in spring and autumn there is not much difference; while in summer nearly half as much again falls by day as by night.

Cape of Good Hope. Report of the Meteorological Commission for the Year 1885. Foolscap folio. vi. + 27 pp. 1886.

This Commission is doing good service by collecting observations from various parts of South Africa. The stations, which are nearly all supplied with Stevenson Thermometer Screens, are inspected by the Secretary in a similar manner to those of the Royal Meteorological Society. The observations may therefore be looked on as comparable with each other. In 1885 the highest temperature recorded at any of the stations was 109°·0 in January at Oudtshoorn, lat. 33°36′ S, long. 22°13′ E, and the lowest 16°·0 in June at Aliwal North, lat. 30°43′ S, long. 26°43′ E, and at Bloemfontein, lat. 28°56′ S, long. 26°18′ E. The greatest rainfall was 77·87 ins. on Table Mountain, 3,050 feet above sea level, and the least 1·58 in. at Port Nolloth, lat. 29°14′ S, long. 16°51′ E. At Pella, in lat. 29°4′ S, long. 19°12 E, rain fell on nine days only during the year.

CIEL ET TERRE. Revue populaire d'Astronomie, de Météorologie et de Physique du Globe. Deuxième Série. 2me Année, Nos. 9-14, July to September 1886. 8vo.

The principal meteorological articles are: Les phénomènes périodiques de la végétation, par C. Ferrari (8 pp.).—Les dépressions atmosphériques (7 pp.).—Influence des masses de neige sur le climat, par A. Woeikof (11 pp.).—Trombe à Bucharest, by Dr. S. Hepites (2 pp.).—Aperçu des travaux scientifiques exécutés à l'Observatoire du Pic du Midi (16 pp.).—Les périodes glaciaires et les variations du climat, par E. Lagrange (18 pp.).—Les zones de température à la surface de la terre (7 pp.).—La transparence de l'air après la pluie, par J. Vincent (2 pp.).

INDIAN METEOROLOGICAL MEMOIRS: being occasional Discussions and Compilations of Meteorological Data relating to India and the Neighbouring Countries. Published under the direction of HENRY F. BLANFORD, F.R.S., Meteorological Reporter to the Government of India. Vol. IV. Part I. 4to. 1886.

Contains:—Account of the South-west Monsoon Storm of the 12th to the 17th of May 1884 in the Bay of Bengal and at Akyab, by J. Eliot, M.A. (38 pp. and 2 plates).—On the Diurnal Variation of the Rainfall at Calcutta, by H. F. Blanford, F.R.S. (8 pp. and plate).—The Meteorological Features of the Southern Part of the Bay of Bengal, by W. L. Dallas (11 pp. and plate).

METEOROLOGISCHE ZEITSCHRIFT. Herausgegeben von der oesterreichischen Gesellschaft für Meteorologie und der deutschen meteorologischen Gesellschaft. Redigirt von Dr. J. HANN und Dr. W. KÖPPEN. Dritter Jahrgang 1886, Heft 7-9, July-September. 4to.

Contains:—Ueber die tägliche Variation des Luftdruckes während des nordischen Winters, von N. Ekholm (5 pp.). The author shows that there is from the observations at Upsala at Cape Thordsen (Spitzbergen) a decided difference in the curve of daily range of pressure when the conditions are cyclonic or anticyclonic respectively, and he points out that this probably extends to other elements.—Die Schwankungen des Wasserstandes im Schwarzen Meer und ihre Ursachen, von Dr. E. Brückner (12 pp.).—Die Luftströmungen über Berlin in der vier Jahreszeiten, nach Dr. F. Vettin (8 pp.). The author states the cumulus occurs at all levels, even above cirrus. The most interesting result is that at all cloud levels, especially the lowest, the northerly component is the strongest, and this motion is not compensated for by the frequence of South-west winds at the earth's surface, as these only affect a very limited stratum. The velocity in the cirrus region is about three times that at the earth's surface, but the increase in rate is irregular, being checked at the level of the lower clouds, evidently owing to the processes of cloud formation going on there.—Bestimmung der Bewegung eines Luftballons durch trigonometrische Messungen von zwei Standpunkten, von Dr. P. Schreiber (5 pp.).—Die Gewitter des oberen Leinethales am 1 Juni 1886, von Dr. H. Meyer (7 pp. and plate).—Thermometer-Aufstellung, von Prof. H. A. Hazen (3 pp.).—Die Vertheilung der Regenmengen in Brasilien, von Prof. F. M. Draenert (11 pp.). The results mainly relate to the southern portion of the empire, and the Atlantic seaboard, where stations are more closely placed than in the interior and along the Amazons.—Die Einwirkung der barometrischen Minima und Maxima auf die Richtung des Windes und Wolkenzuges, dargestellt nach den telegraphischen Wetterberichten der deutschen Seewarte und den einigen Wolkenmessungen in Berlin während des Jahres Mai 1883-84, von Dr. Vettin (11 pp. and plate). The author states the principal result thus:—"From all these Tables it appears that in the region of the barometric depressions and the maxima, we have not exclusively cyclonic and anticyclonic motions, but there are also other currents of a higher order (Westerly, and in the lowest stratum also Easterly) which pass through and make their influence to be distinctly perceived in the observations."—Tägliche Drehung des Wolkenzuges, von A. Richter (5 pp.).

NOVA ACTA REGIÆ SOCIETATIS SCIENTIARUM UPSALIENSIS. Ser. III. 4to. 1886.

Contains:—Sur une nouvelle méthode de faire des mesures absolues de la chaleur rayonnante ainsi qu'un instrument pour enregistrer la radiation solaire, par K. Angström (17 pp. and plate).

Observations of the International Polar Expeditions, 1882-83. Fort Rae. 4to. 1886.

Fort Rae formed one of the series of circumpolar positions, occupied in accordance with the scheme proposed by the late Lieut. C. Weyprecht for concerted physical observations to be carried on for at least a full year, at different stations situated around the Poles. The expense of the expedition was defrayed by grants from the British Government, and from the Government of the Dominion of Canada. Capt. H. P. Dawson, R.A., was appointed to command the party, which consisted of three observers. Fort Rae is one of the posts of the Hudson's Bay Company, and is situated in lat. 62° 38′ 52″ N, and long. 115° 43′ 50″ W, on a bay on the northern shore of the Great Slave Lake. The observations extended from September 1st, 1882, to August 31st, 1883.

Report on the Meteorology of India in 1884. By Henry F. Blanford, F.R.S., Meteorological Reporter to the Government of India. Tenth Year. 4to. 1886. 458 pp. and 4 plates.

This system now comprises 134 meteorological observatories and 478 rainfall stations. The year 1884 was characterised throughout by a remarkable deficiency of insolation, greater even than that of the preceding year. The mean air temperature has undergone a similar but smaller fall. On the average of all parts of the area, 1884 was a cooler year than 1883, and both were considerably cooler than any other year subsequent to 1874. The absolute humidity of the air was rather below the average, and the cloud proportion was also somewhat less than usual. But the rainfall was, on the whole, in excess, owing mainly to the heavy precipitation of North-western and Central India and the Carnatic; for Bengal and the Eastern Provinces generally had less than the average.

Results of Rain and River Observations made in New South Wales during 1885: H. C. Russell, B.A., F.R.A.S., Government Astronomer for New South Wales. 8vo. 1886. 80 pp. and 8 plates.

The number of rainfall stations in New South Wales now amounts to 641. In addition to the monthly and annual rainfall for the year 1885, there is a return showing the annual rainfall at all stations with three years' and up to fourteen years' records (1872-1885), and also a table giving the rainfall records in Australia from 1822 to 1885. Mr. Russell now considers that the annual average rainfall of the colony is 26 inches.

Symons's Monthly Meteorological Magazine. Vol. XXI. Nos. 246-248. July-September 1886. 8vo.

The principal articles are:—Climatological Returns from Japan (3 pp.).—The Sonnblick Observatory (2 pp.).—Temperature Observations on Lincoln Cathedral (1 p.).—The Volcanic Phenomena in New Zealand (5 pp.).—Particulars of the Flood of May 14th to 16th, 1886, as observed on the River Severn between Stourport and Gloucester, and compared with the Winter Floods of 1770 and 1852, by H. J. Marten (3 pp.).—On the Climate of the British Empire during 1885 (3 pp.).—Polar Meteorological Observations (6 pp.).—Whirlwind and Waterspout in South Wales (3 pp.).—A Shower of Snails (2 pp.).

Transactions and Proceedings and Report of the Royal Society of South Australia. Vol. VIII. 8vo. 1886.

Contains the following papers on meteorological subjects:—Notes on Irridescent Clouds, by W. A. Jones (8 pp.).—A Few Remarks about Weather Forecasting for South Australia, by W. E. Cooke, B.A. (4 pp.). The author thinks that it would be premature to issue forecasts at present until the behaviour of storms between Leeuwin and Eucla is more thoroughly understood, and this can only be done by careful inspection every day of isobar maps of the entire continent, such as are displayed in the hall of the Post Office, Adelaide, and by carefully noting the weather accompanying certain recognised forms of disturbance.

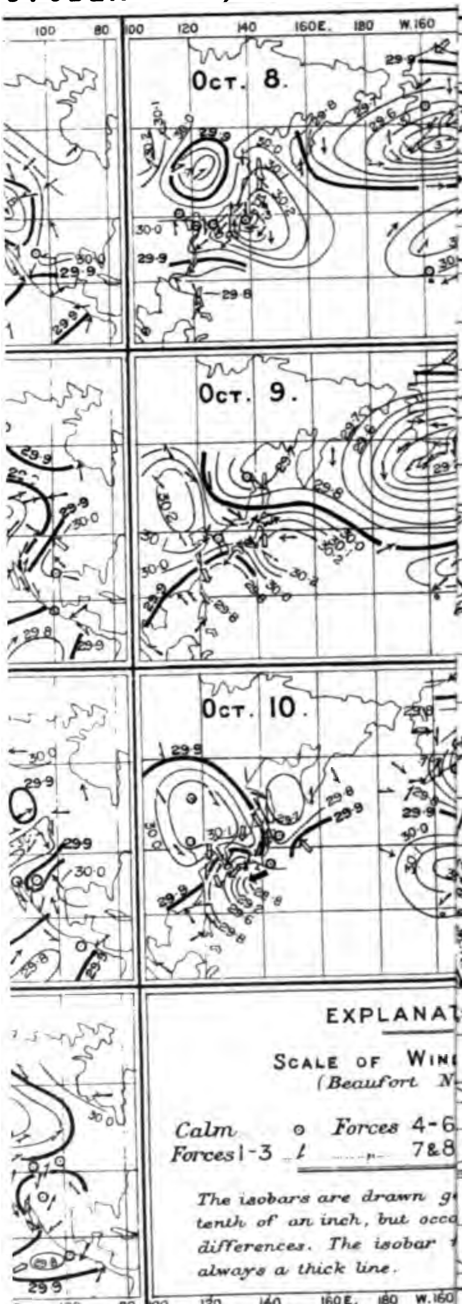
Transactions of the Croydon Microscopical and Natural History Club, 1886. 8vo.

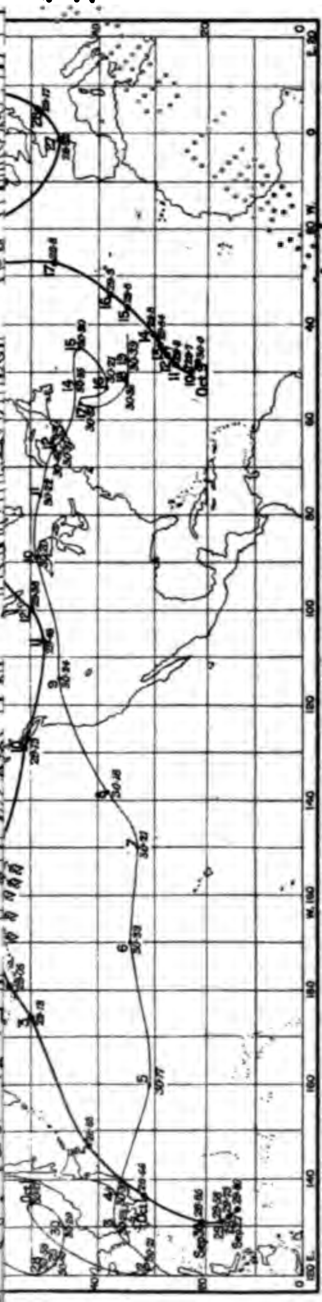
This contains a Report of the Meteorological Committee on the temperature and the rainfall of the Croydon District for the five years 1881-85, prepared by H. S. Eaton, M.A., Secretary (34 pp.).

INDEX.

THE END.

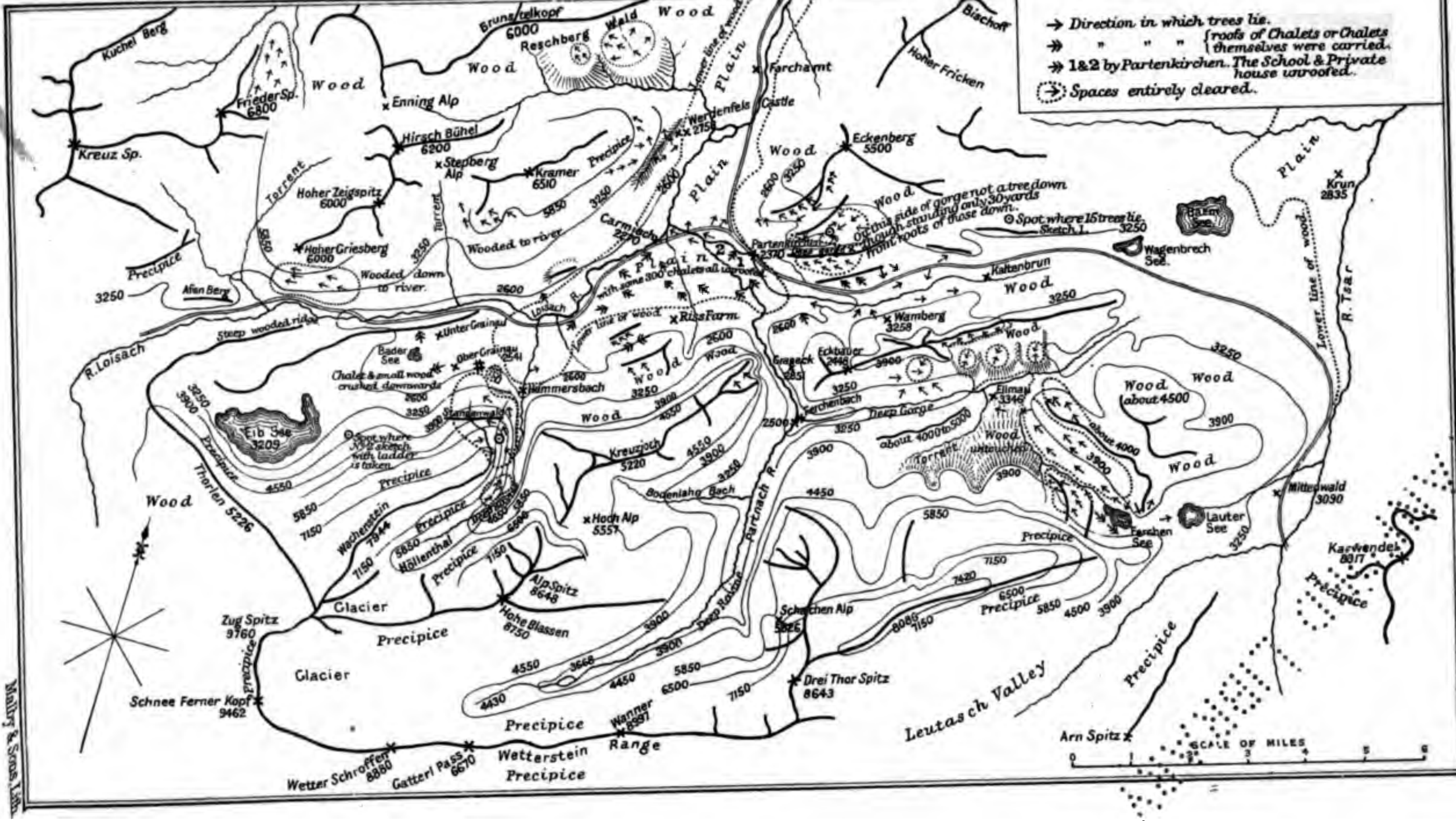
CTOBER 10TH, 1882.





The thick line shows the track of the Typhoon, the thin line that of the Anticyclone. The dates, and the lowest and highest ascertained readings of the barometer for the day being given near the positions of the centres at Greenwich Noon.

MAP SHOWING DAMAGE DONE BY THE STORM



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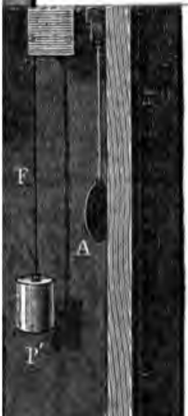
METERS

ying Aneroid. Wallis's Barometer Adjunct.



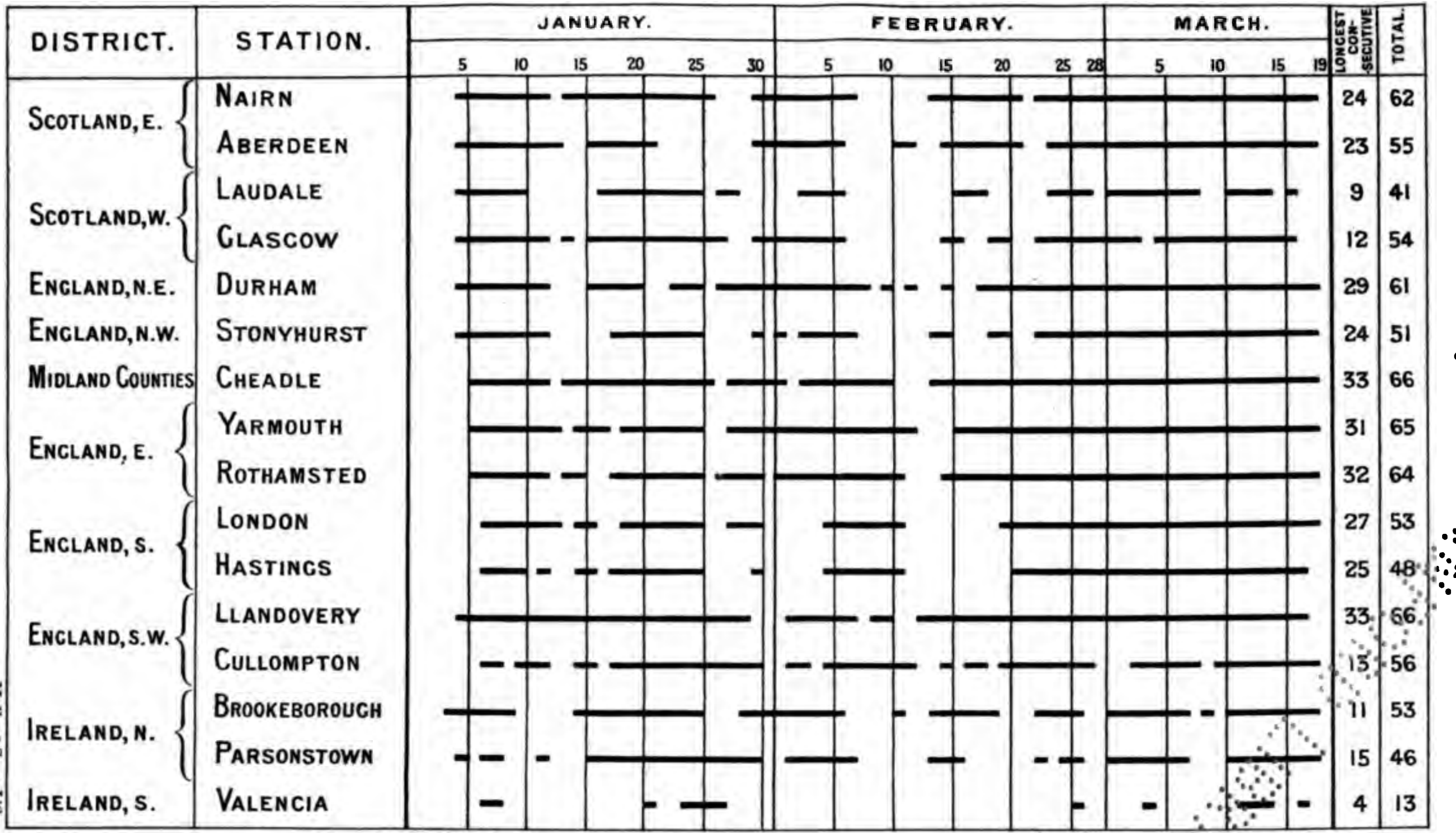
ograph.

Fig. 20.
ono-Barometer and Chrono-Thermometer.

Fig. 22.
Hicks's Flexible Barometer.

Quart. Journ. Roy. Met. Soc. Vol. XII, Pl. 4.

FROSTY NIGHTS_JANUARY TO MARCH, 1886.



The thick line indicates that the minimum temperature was 32° or below.

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